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COMPETITION STUDIES BETWEEN THREE SYMPATRIC SPECIES OF *DROSOPHILA*

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(Received 5 August 1984)

Drosophila rajasekari and *D. malerkotliana* of the subenus *Sophophora* and *D. nasuta nasuta* of the subgenus *Drosophila* enjoy sympatric distribution in peninsular India. Nature of competitive interaction, under laboratory conditions, among these sympatric species of *Drosophila* has been analysed and the results of these experiments are presented in this paper.

(Key words: Drosophile rajasekari, Drosophila malerkotliana, Drosophila nasuta, Sophophora, sympatric distribution, competitive interaction)

INTRODUCTION

Analysis of the natural populations of *Drosophila* reveal that apparently many species coexist in nature. Survey of the South Indian populations have exposed that the members of the subgenera *Sophophora* and *Drosophila* dominate the faunal constellations (REDDY, 1973; GOWDA, 1979; PRAKASH, 1980; MUNIYAPPA, 1982; GAI & KRISHNAMURTHY, 1982-1983). Further, REDDY (1973), RANGANATH & KRISHNAMURTHY (1972), HEGDE & KRISHNAMURTHY (unpublished) and PRAKASH (1980) have studied the monthly variations in the natural populations of *Drosophila* and have tried to assess the impact of physical parameters on the population fluctuations. However, these studies do not include the evaluation of the possible role of competitive interactions between species on the population oscillations.

The understanding of the competitive relationships between closely related species and its appreciation is of considerable evolutionary importance (PARSONS, 1973). An important component of the environment of a population is the presence of other species with which it may compete for available resources of food and living space. The relative abundance of a species is dependent upon the kind and abundance of the species around it (RAJASEKARASETTY *et al.*, 1982a, b).

In the light of these, it was considered of interest to study the competitive interactions in some species of *Drosophila* which are prevalent in Peninsular India. For this study, *D. rajasekari*, and *D. malerkotliana* of the subgenus *Sophophora* and *D. n. nasuta* of the subgenus *Drosophila* have been selected as these are found to be sympatric in most of the natural populations. This paper embodies the results of the experiments conducted to assess the 'adaptedness' of these three species during inter- and intra-specific competitive interactions.

* Deceased, 1982

MATERIALS AND METHODS

Three sympatric species of *Drosophila* namely *D. rajasekari*, *D. malerkotliana* and *D. nasuta nasuta* have been employed for the present experiment. All these three stocks originated from the collections from Mysore area (Karnataka, India).

Two related measures of adaptedness, namely productivity and populaton size were estimated in the above mentioned species during inter- and intra-specific competitions. For these, the populations were maintained following the serial transfer procedure of AYALA (1965) at 22°C.

Each population was built with 25 pairs of flies of a single species and 12 females and 13 males of each species in mixed cultures. The adult flies were introduced in half-pint milk bottles containing wheat cream agar medium seeded with yeast. Once in seven days, flies were etherized, counted and transferred to fresh media bottles. When the emergence began in the bottles where the adult flies have deposited eggs, the newly emerged flies were etherized, counted and added to the bottle with the adult flies. Each bottle is discarded after 4 weeks. Four replicates were maintained for each experiment.

The pure cultures of each species were maintained for twelve weeks. The mean values for productivity and population size were calculated for the three species under study for this period. On the other hand, the mixed culture were maintained till the elimination of one of the competing species.

In the mixed cultures of *D. rajasekari*/*D. malerkotliana*, the females of these species need more time for precise identification, while males can be differentiated easily. Because of this, at each census, for this pair of species, only the number of males of the two competing species and the overall population size were recorded. On the other hand, in the mixed cultures of *D. rajasekari*/*D. n. nasuta* and *D. malerkotliana*/*D. n. nasuta*, both the males and females of these are distinguishable and hence at each counting the total number of each species was recorded.

From these records, the mean values for productivity and population sizes were calculated. Then test for analysis of variance was applied to ascertain homogeneity or heterogeneit among the replicates of each population and between populations of different species.

OBSERVATIONS

The overall adaptedness of the species under study has been assessed by way of estimating their productivity and population size during inter- and intraspecific competitions. *D. malerkotliana* tops the list for both the parameters over *D. rajasekari* and *D. n. nasuta* in their pure cultures (Table 1). The means for productivity of these species are 91.27, 61.88 and 52.88 respectively and similarly for the population size the figures are 195.62, 154.68 and 70.54

TABLE 1. Mean values along with the standard errors of the productivity and population size in three species population in their pure culture.

Populations	Productivity	Population size
	D. rajasekari	
1	57.00	140.50
2	74.09	172.33
3	66.63	169.41
4	49.81	136.50
Mean ± SE	61.88 ± 5.33	154.68 ± 9.39
	D. malerkotliana	
5	79.00	165.25
6	95.00	208.41
7	100.09	208.50
8	91.00	200.33
Mean ± SE	91.27 ± 4.49	195.62 ± 10.30
	D. n. nasuta	
9	34.72	49.83
10	27.18	49.50
11	86.90	105.83
12	62.33	77.00
Mean ± SE	52.88 ± 13.65	70.54 ± 13.41

respectively. Analysis of variance for the data in Table 1 revealed homogeniety among the replicates of each population and significant heterogeneity between populations of these species.

In the interspecific competitions between *D. rajasekari* and *D. malerkotliana*, the former eliminated the latter within a period of 10 weeks. During the course of the interspecific competition, *D. rajasekari* has 23.39 and 46.54 as means (males only) for its productivity and population size respectively. In contrast to this, its competitor *D. malerkotliana* has 14.30 and 25.78 as the averages for the same parameters (Table 2).

TABLE 2. Mean values along with the standard errors of the productivity and population size of *D. rajasekari* and *D. malerkotliana* in their mixed cultures.

Populations	Productivity	Population size
	D rajasekari (Males only)	
13	26.77	62.30
14	19.71	45.62
15	22.37	43.00
16	24.71	31.25
Mean ± SE	23.39 ± 1.51	46.54 ± 6.48
	D. malerkotliana (Males only)	
13	7.88	12.10
14	17.14	29.87
15	17.50	38.55
16	14.71	22.62
Mean ± SE	14.30 ± 2.22	25.78 ± 5.60
	D. rajasekari + *D. malerkotlinna* (Both Males & Females)	
13	76.11	169.90
14	73.85	164.87
15	87.87	181.55
16	94.00	174.00
Mean ± SE	82.95 ± 4.79	172.58 ± 3.52

In the mixed culures of *D. rajasekari* and *D. n. nasuta*, the former species survives by expunging the latter species. The time consumed to outvie *D. n. nasuta* by *D. rajasekari* was 31 to 35 weeks. Here, the means for productivity and population size are 25.79 and 52.07 respectively for *D. rajasekari* while that of *D. n. nasuta* are 20.04 and 35.06 respectively (Table 3).

TABLE 3. Mean values along with standard errors of the productivity and population size of *D. rajasekari* and *D. n. nasuta* in their mixed cultures.

Populations	Productivity	population size
	D. rajasekari	
17	20.90	46.31
18	24.57	49.38
19	30.90	59.87
20	26.76	52.74
Mean ± SE	25.79 ± 2.10	52.07 ± 2.91
	E. n. nasuta	
17	19.83	34.68
18	25.33	40.70
19	19.50	35.87
20	15.52	29.00
Mean ± SE	20.04 ± 2.01	35.06 ± 2.40

The interspecific competition between *D. malerkotliana* and *D. n. nasuta* revealed the survival of *D. malerkotliana* only. Both the species stayed together for a period of 36 weeks before *D. n. nasuta* was eliminated. The means for productivity and population size are 88.46 and 138.04 respectively for *D. malerkotliana* and 17.57 and 29.11 respectively for *D. n. nasuta* (Table 4).

TABLE 4. Mean values along with the standard errors of the productivity and population size of *D. mrlerkotliana* and *D. n. nasuta* in their mixed cultures.

Population	Productivity	Population size
	D. malerkotliana	
21	99.86	146.91
22	84.68	134.03
23	61.48	101.02
24	107.59	170.21
Mean ± SE	88.46 ± 10.15	138.04 ± 14.43
	D. n. nasuta	
21	20.86	33.86
22	16.03	26.51
23	19.31	37.58
24	13.88	18.50
Mean ± SE	17.57 ± 1.57	29.11 ± 4.21

DISCUSSION

Species closely related phylogenetically and ecologically have frequently been observed to coexist in the same habitat, apparently exploiting the same resources and there will be competitive interactions between them. Then performance in competition may be used as a measure of population fitness of the species concerned. Laboratory populations can be utilized as biological models to study the dynamics and the process of competition.

Adaptedness refers to the ability of the carriers of a genotype or a group of genotypes to survive and reproduce in a given environment (DOBZHANSKY, 1968). Two related mearures of adaptedness can be obtained, namely, 'productivity' and population size, in experimental populations (AYALA, 1965). Productivity is the extent of its reproductive potential, measured in terms of new-born flies every week. So it is the sum total of various components of life cycle such as fecundity, hatachability rate of development, etc. Population size is measured in terms of average population size it maintains during the experimental period. In addition to the above mentioned components of productivity, it also includes the events like viability, longevity and sexual activity of the adults. The populations which maintain a larger population size may be said to be performing better from biological point of view than the one having small population size. Hence, this provides means for comparing the overall biological performance of one population with another, where both are maintained under similar environmental conditions.

In the present experiments, the productivity and population size have been measured during inter- and intraspecific competitions of the three sympatric species under study, *D. rajasekari*, *D. malerkotliana* and *D. n. nasuta*. In the pure cultures, *D. malerkotliana* possess the highest productivity and population size while *D. n. nasuta* has the least. Therefore, the sequence is *D. malerkotliana* > *D. rajasekari* > *D n. nasuta*. But in the mixed cultures i.e., during interspecific competion, the fitness of *D. rajasekari* is shown to be significantly superior to that of *D. malerkotliana*, wherein the latter is expunged within a course of ten weeks. In these mixed cultures, the productivity and population size of *D. rajasekari* are significantly more than that of *D. malerkotliana*. On the other hand, both *D. rajasekari* and *D. malerkotliana* have maintained their superiority over *D. n. nasuta* in their mixed cultures as

it was in their pure cultures. Both *D. rajasekari* and *D. malerkotliana* have eliminated *D. n. nasuta* and to achieve this they have taken 36 and 35 weeks respectively. The performance of *D. rajasekari* and *D. malerkotliana* in their mixed cultures with *D. n. nasuta* reveal that *D. malerkotliana* has a better population size and productivity than *D. rajasekari*. Further, the adaptedness of *D n nasuta* even though it is a looser, is slightly better against *D rajasekari* than against *D malerkotliana*. Therefore, *D. malerkoliana* has inhibited more effectively the growth of *D. n nasuta* than *D. rajasekari*.

These results embody evidences both for positive and negative correlations for adaptedness of species in pure and mixed cultures. In both the conditions, *D. rajasekari* and *D. malerkotliana* maintain their superiority over *D. n. nasuta*. But, *D. malekotliana* has a better adaptedness than *D rajasekari* in pure cultures, but in mixed cultures *D. rajasekari* proves to be better than *D. malerkotliana*.

Acknowledgements: Authors are grateful to Prof. N. B. KRISHNAMURTHY, Head of the Department of Post-Graduate Studies and Research in Zoology, University of Mysore, Manasa Gangotri, Mysore for his help and encouragement.

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ON SOME LITTLE KNOWN AND A NEW PRAYING MANTID (MANTODEA) FROM MULLA - PERIYAR TIGER RESERVE, KERALA, INDIA

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(Received 2 September 1984)

This paper records 8 species of praying mantids of which 2 are new records from India and a species *Hapalopeza periyara* is described as new to science.

(Key words: praying mantids, Mantodea, *Hapalopeza periyara)*

The southern India, specifically Nilgiri and Anamalai Hills provides good tropical rainforest. Approximately one seventh of total Indian record of praying mantids are known from these states. Still more of them are expected to inhabit this area. The specimens were collected by Dr. R. S. Pillai and Dr. K. Mathew and party of Zoological Survey of India, Madras during Mullaperiyar Expedition 1981 for which we are grateful to them.

Family : Mantidae Burmeister 1838
Sub-family : Mantinae Kirby 1904
Tribe : Mantini Beier 1964.

Tenodera fasciata (Oliver) 1792

1792. *Mantis fasciata* Oliver : *Enc. moth.*, 7:640

1802. *Mantis leptelytra*, Lichtenstein : *Tr. Linn: Soc. London.*, **6**:20

1831. *Thespis fasciata*, Serville : *Ann. Sci. nat.*, **22**:55

1838. *Mantis (Tenodera) fasciata*, Burmeister ; *Handb. Ent.* **2**:534

1904. *Mesopteryx fasciata*, Kirby : *Cat. Orth. Brit Mus.*, **1**:238

1912. *Tenodera fasciata*, Giglio-Tos *Bull. Soc. ent. Ital.*, **43**.45

Material: 1 ex., ♂, Sethayanaodai Coll. K. Mathew and party 18.ii.1981, Stn. 1, lot, 13, Sl. No. 13/MPR.

Remarks: This species has very narrow frontal seterite which is more than twice wider than high, bicarinate. Margins of pronotum and coxae smooth. Carina of pronotum indistinct. All spines of anterior femur black at tips only. There is no colouration of black patches on anterior femur. Elytra longer than body; costal area opaque and anterior half of discoidal area densely reticulate. The transverse veinules of costal area of wings characteristically blood-red and there is no reddish patch at the basal area.

Tenodera bokiana (Gigl. Tos) 1907

1907. *Stenopyga bokiana*, Giglio-Tos; *Boll. Mus. Torino*, **22**(563):12.

1908. *Agrionopsis bokiana*, Werner; *Ber. Senckenb. Ges:* 42.

* Present address: Department of Zoology, Jhargram Raj College, Midnapore, West Bengal.

1912. *Tenodera superstitiosa* var. *bokiana*, Giglio-Tos: *Bull. Soc. ent. Ital:* **43**:44

1927. *Tenodera bokiana* Giglio-Tos: *Das Tierreich*, **50** Lief : 416.

Material: i) 1 ex. Sethayaodai, Coll. K. Mathew and party, 18.ii.1981, Stn. 1, lot 13 Sl. No. 13/MPR.

ii) 3 exs. (2 ♂♂, 1 ♀) Manakavalla, Distt. Thekkadi, Coll. K. Mathew and party, 19.ii.1981, Stn. 1, lot 14, Sl. No. 16/MPR.

iii) 3 exs., 2 km. South to Edapalayam, Coll. R. S. Pillai and party 28.ii.1982, Stn. 2 lot 4, Sl. No. 24/MPR.

Remarks: The previous distribution was recorded in Africa, Australia and Singapore. It is for the first time recorded from India. This species is characterised by the presence of black femoral bloch and an obliquely elongated black patch in front of claw groove from the base of first small internal spine; the totally black first three discoidal spines and bigger internal spines latter exhibit extension as black parallel lines.

Tenodera blanchardi Giglio-Tos 1912

1838. *Mantis (Tenodera) fasciata* Burmeister: *Handb. Ent.*, **2**:534

1853. *Mantis costalis*, Blanchard : *Voy pöle Sud*, **4**:353

1912. *Tenodera Blanchardi*, Giglio-Tos: *Bull. Soc. ent. Ital.* **43**:46

Material: 2 ♂♂, Manakavalla, Coll. K. Mathew and party, 19.ii.1981, Stn. 1, lot 14, Sl. No. 16/MPR.

Remarks: This species was previously known from Borneo, Celebes. Ceram, New Guinea, Amboine etc. It is a new record from India. It can be recognised by the presence of an almost oval black spot in front of claw groove. The first smaller internal spine on groove is black by this patch; the bigger internal spines are black. The first discoidal spine is black except near base and rest three are black at tips only.

Tenodera aridifolia (Stoll) 1713

1813. *Mantis aridifolia* Stoll : *Represent, Spectres:* 65, t/22 f. 82.

1838. *Mantis chloreudeta*, Burmeister : *Handb. Ent.* 2: 535

1872. *Tenodera aridifolia*, Saussure : *Mem. Soc. Geneve* **23**:49.

Material: 2 exs. nymphs, East to boat landing, Periyar, Coll. K. Mathew and party, 21.ii.1981, Stn. 1, lot 16, Sl. No. 19/MPR.

Remarks: This is the commonest species of the genus *Tenodera* found all over the Oriental Asia. Frontal sclerite a little wider than high; anterior coxa spinous; spines of anterior femur black at tips only.

Statilia nemoralis (Sauss.) 1870

1870. *Pseudomantis nemoralis* Saussure: *Mt. Schweiz. ent. Ges.*, **3**, 229

1877. *Statilia nemoralis*, Stall: *Bih. Svenska Ak.*, **4** (10), 55.

Material: 1 ex., Anguruli, Coll. K. Mathew and party, 14.ii.1981, Stn. 1, Lot 8, Sl. No. 6/MPR.

Remarks: This is a common species of Oriental Asia. This differs from rest two Indian species by the absence of black band on prosternum, hyaline wings with stigma marked by black spot at corners. Internal spines of anterior femur with black rings at bases.

Sub-Family: Tarachodinae Handlirsch 1930

Didymocorypha lanceolata (Fabr.) 1798

1798. *Mantis lanceolata*, Fabricius: *Ent. syst., suppl.* 191

1877. *Schizocephala (Didymocorypha) ensifera*, Wood-Mason: *Ann. nat. Hist.*, **19** (4), 222

1877. *Pyrgocotis gracilipes*, Stall: *Bih. Svenska Ak.* **4** (10), 17.

1882. *Didymocorypha ensifera*, Wood-Mason: *J. Asiat. Soc. Bengal* **51**, 24

1889. *Pyrgocotis ensifera*, Westwood: *Revis. Mantid*, 3

1897. *Didymocorypha lanceolata*, Bolivar: *Ann. Soc. ent. France*, **66**, 303.

Material: 1 ex. ♂; from 1½ km. West to Edapalayam I.B., Coll. R. S. Pillai and party, 27.ii.1981, Stn. 2, lot 2, Sl. No. 23 MPR.

Remarks: The genus *Didymocorypha* characteristically has much prolonged juxtacular lobes in the form of triangular processes. Only one species is so far known from southern India and Ceylon. Frontal sclerite about 1½ times longer than high in the middle. The eyes are laterally placed; left juxtacular process is a little longer than the right one. Anterior femur with 4 external and 4 discoidal spines, all black at tips only; anterior tibia with 5 external spines. Pronotum with almost parallel margins; carina of metazona is fine, linear.

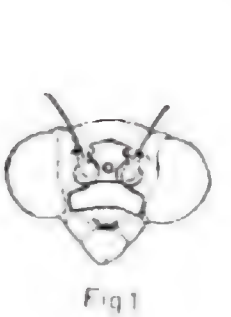
Sub-family : Iridopteryginae Giglio-Tos 1919

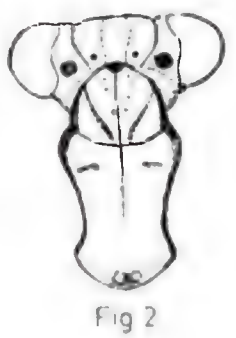
Tribe : Iridopterygini Beier 1964

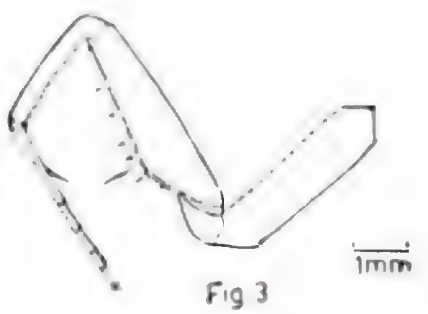
Hapalopeza periyara sp. nov. (Text figs. 1—3)

Female: Brownish black, total length 14.0 mm, wing span 28.5 mm., Frontal sclerite feebly arched with nearly straight upper margin in middle; inferior border concave; surface is brown. Vertex with straight upper margin and 4 grooved, raised a little beyond the eyes. There are 4 black spots along the posterior margin of vertex lobes (Fig. 2) the two laterals or the juxtacular lobes are bigger. The lobes are separated by faint grooves. Ocelli black at their dorsal and lateral sides. The second antennal segment is distally black.

Pronotum: This is shorter than anterior coxa. Prozona dorsally at anterior end is coloured blackish. The prozonal edge is blackened and continues at end of metazona. The posterior edge







Figs. 1—3. *Hapalopeza periyara* sp. nov. 1. Front view of head of *Hapalopeza periyara* sp. nov.; 2. Dorsal view of pronotum showing black line on edges and posterior view of head showing black round patches on lobes of vertex of *H. periyara* sp. nov.; 3. Outer view of left fore leg of *H. periyara* sp. nov.

of metazona dorsally bears two flattened and round tubercles and coloured black, Both meso- and metapleura bear black dots. Supracoxal dilation much pronounced; metazona constricted in the middle. Metazona at anterior half with a pit on each side. The lateral sides of neck overhung by prozona contain black spots. Pronotum dorsally without any carina.

Anterior leg: Entirely brown; coxa with few bristles. Femur with 3 discoidal and 4 external spines; latter bigger than those in *H. nilgirica* w.-Mas. Rest spines are black at tips only. Tibia with 9 external spines.

The disk of femur bears a small spine occupying the position of discoidal spine and of same size as that of first (proximal) discoidal spine. Thus there will be 4 discoidal spine when the former is counted together.

The distal tarsal segments are blackish except the proximal one.

Middle and hindlegs: Femoral and tibial junctions are blackish. Posterior metatarsus as long as remaining segments together.

Elytra and wings: Elytra and wings longer than body. There is a black line at the base of elytra. Veins are blackish as in *H. nilgirica* W.-Mas.

Others: Supra anal plate is distinctly triangular and nearly pointed at tip. Cerci cylindrical and few distal segments are internally black.

Measurements: ♀; Body-14.0 mm, Pronotum-4.5 mm, Metazona-2.5 mm, Ant. coxa-3.0 mm, Ant. femur-3.9 mm, Ant. tibia-2.0 mm, Elytra-13.5 mm.

Distribution: India : Kerala.

Type locality: *Holotype* ♀: India: Kerala, Periyar lake; coll. K. Mathew and party, Alt. 880 mtrs. 11.ii.1981, Stn. 1, lot 2, Sl. No. 3/MPR, 2 exs.; deposited in the National Zoological collection of Zoological Survey of India, Calcutta. Regd. No. 10043/45.

Comparison: This species differs distinctly by the shape of supra- anal plate which is almost pointed; but truncated round in *H. nilgirica* W.-Mas 1891; also by the presence colouration on the vertex lobes.

Subfamily : Amelinae Giglio-Tos 1919

Tribe : Amelini Beier 1964

Amantis saussurei (Bol.) 1897

1897. *Iridopteryx saussurei*, Bolivar : *Ann. Soc. ent. France*, **66**:305

1904. *Gonypeta saussurei*, Kirby : *Cat. Orth. Brit. Mus.*, **1**:224.

1927. *Amantis saussurei*, Giglo-Tos : *Das Tierreich 50 Lief*: 171.

Material: 1 ex., Valiyathura, Kerala, Coll. K. R. Rao, 8.iii.1981, Stn. 3, lot 3, Sl. No. 33/MPR

Remarks: Vertex scattered black. Frontal sclerite with two black dots on either sides. From the inferior ocellus a black line extends along middle of frontal solerite. This is common species of this genus.

Family : Homenopodidae Chopard 1949

Sub-family : Acromantinae Giglio-Tos 1919

Tribe : Acromantini Beier 1964

Ephestiasula amoena (Bol.) 1897

1897. *Pachymantis amoena*, Bolivar : *Ann. Soc. ent. France*, **66**: 314.

1915. *Ephestiasula amoena*,Giglio-Tos : *Bull. Soc. ent. Ital.*, **46**: 101.

Material: 1 ex., $\frac{1}{2}$ km West of Edapalayam I. B. Alt. 880 mts. coll. R. S. Pillai and party, 27.ii.1981, Stn. 2, lot 2, Sl. No. 23/MPR.

Remarks: Internally the entire dorsal area of anterior femur is blackwish and the inferior area contains only two black spots on a yellow ground colour. Internal spines are entirely blackish, even at bases. Tip of prozona with two symmetrical longitudinal but short black patch-the middle being brown. A black spot on mid-posterior end of pronotum. Vertex with a minute tubercle; juxtacular lobes ore cone-shaped and black.

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STUDIES ON THE DAMAGE AND CHEMICAL CONTROL OF THE WEEVIL *CYRTOZEMIA DISPAR* PASC ON SOME LEGUME CROPS

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Extent of natural damage by *Cyrtozemia dispar* and *C. cognata* to five kharif legume crops was studied. Moong and clusterbean were damaged more in field. In laboratory feeding trials with *C. dispar*, maximum leaf area was consumed in first 24 hours and the consumption decreased when the same plants were exposed to weevils for another 48 hours. Healthy leaves were prefered and consumed more than the previously weevil-affected leaves. Methyl parathion, fenitrothion, quinalphos, carbaryl, monocrotophos, phosphamidon and lindane proved effective against *C. dispar* upto one week after treatment.

(Key words: natural damage, chemical control, *Cyrtozemia* weevil, legume crops, feeding preference)

INTRODUCTION

The moong weevil, *Cyrtozemia dispar* Pasc, is an important insect pest of many kharif legume crops in the arid and semi arid regions of Rajasthan. The weevil makes circular to irregular holes in leaves. PAL (1972) has reported *C. cognata* Mshl infesting kharif crops in dryland farming, while SRIVASTAVA *et al.* (1975) have recorded *C. dispar* and *C. cognata* occurring on vegetable guar. PAL & KUSHWAHA (1977) studied toxicity of some insecticides to the adults of *C. cognata* Mshl. However, no information is available about the extent of damage done to various crops. The present investigations, therefore, were undertaken to study the relative damage to different host plants at different stages of crop growth and feeding preference of weevils under different conditions of host availabilty. In addition, commonly used insecticides have been evaluated for their effectiveness against *C. dispar* adult weevils.

MATERIALS AND METHODS

Experiments were carried out at the Central Research Farm and Toxicology laboratory of the Central Arid Zone Research Institute, Jodhpur, during kharif (rainy season) 1980. Three leaves were randomly collected from each of the five plants of each host crop viz., clusterbean or guar, cowpea, kidneybean, moong and mothbean, which constituted one replicate. Four such replications were taken randomly selecting the plants from un-treated crops, regardless of cultivar strain. The collected leaves were observed for the damage of weevils. The total leaf area and leaf area devoured by the weevils was drawn on square paper and measured. Per cent foliage loss to different crops was calculated from these data. Observations were taken twice, first when the crops were two weeks old and the second when crops were one month old.

To find out the relative consumption of different host plants by *Cyrtozemia dispar* Pasc the weevils collected from field were starved

for 6 hours and were released in wiregauge cages (15 cm × 15 cm × 15 cm) containing one week old plants of the five host crops embedded in beakers filled with watered soil. In each cage five starved weevils wre released which constitute one replicate. Four replications were made for each of the five hots plants fed. Feeding was done for 72 hours. After every 24 hours leaf area consumed by the weevils was measured and the same plants were kept in cages for further feeding by the weevils.

To study the relative consumption of healthy and already weevil - affected leaves by *C. dispar*, another feeding trial was carried out. The starved weevils were allowed to feed separately on healthy and previously weevil-damaged leaves for 24 hours, in 250 ml beakers containing moist soil at bottom and covered with muslin cloth at the top. In all the four replications for both types of leaves fed, five starved weevils were released in one beaker, representing one replicate. The area of both types of leaves consumed during 24 hours was calculated by comparing the total leaf area drawn on paper before and after feeding.

For evaluating insecticidal efficacy a field trial was laid out in randomised block design. Guar plants in single row of 3 m were sprayed to run off stage with insecticides (with water in control rows) in concentrations as shown in Table 4. Each treated row, representing one replicate, was separated by five untreated rows to avoid contamination by drift. Each treatment was replicated thrice. Leaves from these plants were fed to the weevils kept in 250 ml beakers. Each beaker contained 15 weevils which were fed with leaves brought from treated (and control) plants in field. Thus, corresponding to respective treatments and replications in field there were 33 beakers. Mortality counts were made after 24 hours exposure of weevils to the treated (water-treated in control) guar leaves. Mortality data were corrected using Abbott's formula (Abbott, 1925) and were analysed statistically after angular transformation where required (Snedecor & Cochran, 1968).

RESULTS AND DISCUSSIONS

Per cent foliar loss under field conditions to 14 and 30 days old crops by *Cyrtozemia dispar* and *C. cognata* has been presented in Table 1. The per cent foliar loss in moong and guar was significantly more than in kidney-bean, mothbean and cowpea in the two

Table 1. Extent of foliage injury to some legume species by moong weevils *Cyrtozemia* spp.

S.No.	Host plant	Per cent foliar loss to* 14 days old crops	30 days old crops
1.	Clusterbean or guar *(Cyamopsis tetragonoloba* L.)	26.58	24.05
2.	Cowpea *(Vigna ungriculata* (L.) (Walp)	18.18	12.96
3.	Kidneybean *(Lablab purpureus* (L.) (Sweet)	19.60	13.73
4.	Moong *(Vigna radiata* (L.) (Wilc.)	27.10	20.93
5.	Mothbean *(Vigna aconitifolia* (Jacq.) (Marechal)	19.23	16.60
	SEm ±	1.71	0.95
	CD ($p = 0.05$)	5.59	3.10

* Mean of four replications

weeks old crops. The combined loss by the two species of weevils in 30 days old crops was more in guar than in moong, though no statistically significant difference occurred between the per cent loss in the two crops. Cowpea was found to be least damaged crop though statistically it was at par with kidneybean. SRIVASTATA *et al.* (1975) reported considerable damage of *C. dispar* and *C. cognata* on clusterbean, whereas *C. cognata* was reported to cause maximum damage to moong and minimum to moth and cowpea (PAL, 1972).

Since in field relative abundance of *Cyrtozemia dispar* was more, the experiment was laid out in laboratory to assess the consumption of leaf area of the five crops by this species only. The data presented in Table 2 reveal that moong leaves were consumed maximum and moth leaves the minimum during first 24 hours. However, statistically, no difference was observed in the leaf area consumed (0-24 hrs) of moong, guar and kidneybean. The leaf consumption of the latter two crops did not differ significantly from that of cowpea.

In the next 24 hours, i.e., between 24–48 hours of feeding, no difference was observed in consumption of kidneybean, guar and moong but these crops were consumed more than cowpea and moth (Table 2). For 24 hour feeding between 48 to 72 hours, no difference was observed in the consumption of any of the five crops as evidenced by the insignificant difference in average leaf area consumed (Table 2).

It may be seen that leaf consumption decreased regularly with passage of time when the same plants were fed to the weevils, as reflected by per cent

TABLE 2. Consumption of different host plants by *Cyrtozemia dispar* Pasc under laboratory conditions.

S.No	Host plant	Average leaf area consumed in cm² ***				
		0–24 hours	24–48 hours	Per cent decrease over last 24 hours ***	48–72 hours	Per cent decrease in consumption over last 24 hrs. ***
1.	Clusterbean	6.15	2.15	62.22	1.28	35.15
2.	Cowpea	5.30	1.38	74.26	1.00	26.18
3.	Kidneybean	5.68	2.30	59.13	1.55	33.42
4.	Moong	6.78	1.98	70.93	1.50	20.22
5.	Mothbean	3.40	0.85	74.65	0.60	18.61
	SEm ±	0.404	0.254	*	*	*
	CD (p = 0.05)	1.318	0.827	*	*	*

* F test insignificant; *** Mean of four replications

reduction in leaf area consumed after 48 and 72 hours (Table 2). These data indicated that the leaves once infested were prefered less than the leaves free of weevil attack. In order to confirm these findings, starved *C. dispar* weevils were fed separately on healthly and weevil - attacked leaves broght from the field. The data on relative consumption of two types of leaves have been presented in Table 3. It may be seen that more leaf area was consumed from the healthy leaves than from previously weevil - affected leaves. Averge per cent reduction in leaf consumption, in the already weevil-affected leaves, although statistically insignificant, ranged from 10.33 per cent in moong to 28.04 per cent in kidneybean. This reduction could be explained by taking into consideration the feeding habit of the weevils which make holes in the leaves rather than feeding on sides as most other chewing insects do. The already attacked leaves contain lesser laminar area available for feeding by making holes and for free movement of the weevils on the leaf surface.

Data on insecticidal evaluation against *C. dispar* have been presented in Table 4. When the leaves from treated plants were fed to the weevils after 24 hours of spray in field, maximum mortality was witnessed in weevils feeding on guar leaves treated with methyl parathion. But statistically no difference in mortality was observed in the weevils feediug on leaves treated with methyl parathion, fenitrothion, carbaryl, monocrotophos and endosulfan. Also, there existed no significant difference in weevil mortality due to carbaryl, monocrotophos, endosulfan, quinalphos, malathion, phosphamidon, lindane and phenthoate (Table 4).

After 48 hours of crop treatment, methyl parathion was found to be superior to all other insecticidal treatments except fenitrothion with which it stood at par. Carbaryl was found

TABLE 3. Consumption of healthy and already weevil affected leaves of different host plants by *Cyrtozemia dispar* Pasc.

S.No	Host plant	Area consumed (cm^2) ***		Per cent reduction in area consumed of the weevil affected leaves ***
		Damaged leaves	Healthy leaves	
1.	Clusterbean	5.23	7.05	25.91
2.	Cowpea	4.90	5.95	17.55
3.	Kidneybean	4.40	6.10	28.04
4.	Moong	6.08	6.78	10.33
5.	Mothbean	2.65	3.55	26.91
	SEm ±	0.434	0.262	*
	CD ($p = 0.05$)	1.147	0.855	*

* F test insignificant; *** Mean of four replications; based on 24 hour's feeding

to be at par with fenitrothion but inferior to methyl parathion. Lindane, malathion, phenthoate and phosphamidon provided least weevil mortality but were at par with quinalphos (Table 4).

Seven days after treatment of crops in field, when the treated leaves were fed to the weevils, insignificant difference was recorded in mortality due to methyl parathion, fenitrothion, quinalphos, carbaryl, monocrotophos, phosphamidon and lindane. Endosulfan, malathion and phenthoate proved to be inferior to the above treatments except the last three with which these stood at par (Table 4). PAL & KUSHWAHA (1977) have reported parathion, carbaryl, lindane and phosphamidon to be effective against another species viz., *Cyrtozemia cognata* on moong crop. Two weeks after crop treatment when weevils were

TABLE 4. Relative efficacy of insecticides against the adult weevils of *Cyrtozemia dispar* Pasc (Mean of 3 replications).

S. No.	Treatment	% concn. a i	Per cent corrected mortality after			
			24 hours	48 hours	7 days	14 days
1.	Carbaryl W P	0.1	84.44 (67.50) *	82.22 (65.37)	67.39 (55.39)	44.45
2.	Endosulfan EC	0.07	80 (63.65)	75.56 (60.75)	57.69 (49.49)	21.15
3.	Fenitrothion EC	0.05	91.11 (72.71)	87.78 (69.59)	72.71 (58.62)	42.09
4.	Lindane EC	0.05	64.45 (53.43)	62.22 (32.10)	59.89 (50.71)	33.97
5.	Malathion EC	0.05	66.67 (54.81)	62.22 (52.10)	57.51 (49.39)	23.72
6.	Methyl parathion EC	0.05	95.55 (80.00)	91.11 (72.87)	72.89 (59.08)	34.48
7.	Monocrotophos EC	0.04	80.00 (63.65)	77.78 (61.92)	67.40 (55.20)	42.31
8.	Phenthoate EC	0.05	64.45 (63.65)	62.22 (61.92)	52.56 (55.20)	21.15
9.	Phosphamidon	0.03	66.67 (54.81)	62.22 (52.10)	60.04 (50.79)	23.72
10.	Quinalphos EC	0.05	71.11 (57.65)	68.89 (56.14)	67.76 (55.55)	44.87
	SEm +	—	6.4	1.92	3.02	3.65
	CD P = 0.05)		18.91	5.66	8.90	10.76

* Figures in parentheses denote angular transformed values of corrected mortality

fed treated leaves, none insecticidal treatments could provide more than 50% mortality. In all the above reported observations all the insecticidal treatments were found to be superior to control.

The results presented above indicate that methyl parathion, fenitrothion, quinalphos, carbaryl, monocrotophos, phosphamidon, and lindane were effective insecticides against *Cyrtozemia dispar* weevils. However, these insecticides could provide protection upto 7 days only after which their effectiveness decreased greatly. The major factor contributing to limited period of effectiveness was occurrence of rains in the season (Table 5) which washed off the insecticides from leaf surface. If a dry spell were to occur after treatment, longer persistence of these insecticides could be expected.

TABLE 5. Weather conditions during experimental period. **

Week	Temp. (°C)		R. H (Mean, %)	Rainfall (mm)
	Max.	Min.		
23–29 July	35.3	26.0	70.0	99.8
30 Jul–5 Aug.	32.4	25.5	78.0	13.9
6–12 Aug.	32.5	25.2	70.5	—
13–19 Aug.	35.0	25.0	59.5	
20–26 Aug.	37.7	25.7	53.5	—
27 Aug–2 Sept.	35.9	25.5	57.5	—
3–9 Sept.	34.0	24.3	60.0	29.2
10–16 Sept.	35.3	24.5	54.5	—
17–23 Sept.	37.0	24.7	50.5	8.2

** Weekly averages

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IMPACT-SENSITIVENESS OF SOIL ORIBATID SPECIES TO THE WASTE WATER FROM A COAL DISTILLATION PLANT

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Three different response patterns were identified for the oribatid species of a field polluted by the industrial waste water on the basis of the shift in the dominance status. *Scheloribates fimbriatoides, Xylobates indicus* and *Galumna flabellifera* were considered to be the most impact-sensitive potential bio-indicator species of soil pollution.

(Key words: impact sensitiveness, soil orbitids, waste water, distillation plant)

INTRODUCTION

AOKI (1979) opined that oribatid species can be utilized as indicator animals to the destruction of natural environments. BHATTACHARYA & BHATTACHARYA (1983) reported that industrial waste water is capable of causing a simplification in the community structure of soil Oribatida by decreasing the number of species, species richness and species diversity. The present communication is concerned with the response patterns of different oribatid species to the impact of industrial waste water. So far the only work in this regard is that of DINDAL (1977) who reported responses of various oribatid species due to municipal waste water irrigation of soil.

MATERIALS AND METHODS

The investigation was done at Kalipur village (23° 30′ N 87° 20′ E) near the effluent drain of Durgapur Projects Ltd., Durgapur, West Bengal. The effluent contains many toxic substances like ammoniacal nitrogen, phenol, sulphide, cyanide etc. (DE *et al.*, 1980) Soil samples were taken from two sites near this drain. First site was located near the drain and was frequently flooded by the drain water. This was considered as 'polluted site'. The second site was located about 100 meters from the drain at a little higher elevation and therefore escaped flooding. This was considered as 'unpolluted site'. Details of the study sites, sampling and extraction of oribatid mites have been considered by BHATTACHARYA & BHATTACHARYA (1983).

To find out the response patttern, the dominance status of various oribatid species encountered in the polluted and the unpolluted sites were compared. Dominance status of a species was ascertained on the basis of relative abundance (% of total Oribatida) following Brockman-Jerosch scale (cf. TAMURA, 1967). Species with relative abundance exceeding 5% were considered as 'dominants', those between 2–5% as 'subdominants' and remaining species were considered as 'rare. Response was considered to be positive (+) if there was a gain in dominance status in the polluted site compared to that in the unpolluted site, as negative (—) if there was a loss in dominance status and neutral or no effect (0) if the species in question maintained same status in both the sites.

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Percentage deviation in abundance were also estimated for those species which were dominant in either of the two sites but exhibited positive or negative responses. For this purpose abundance in the unpolluted site was converted into 100 and relative deviation in the polluted site was calculated.

RESULTS AND DISCUSSION

Out or a total of 55 oribatid species recorded from the study sites, 33 species were found in the polluted site and 49 species were encountered in the unpolluted site. Twenty seven species were common to both the sites, When dominance status of the species were considered, it was found that in the unpolluted sites 6 species were 'dominant, 5 were 'subdominant' and 38 species were 'rare'. Similarly in the polluted site 7 species were 'dominant' and remaining 26 species were 'rare'. There was no species which could be designated as 'subdominant' in the polluted site.

A comparative picture of the dominance status of different oribatid species of the polluted and the unpolluted sites, together with their response patterns are shown in Fig. 1. Out of the 27 species which were present in

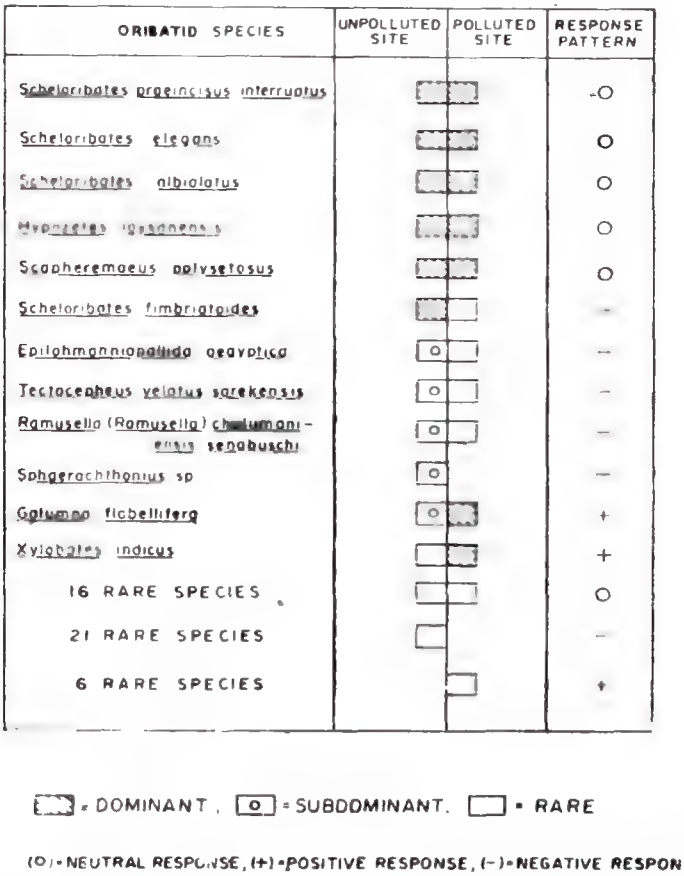

Fig. 1. Dominance status of different oribatid species of the study sites and their response patterns.

both the sites, in 21 species (5 dominant and 16 rare) no change in the dominance status could be noted. In other words they were neutral in response. Thus these species can be considered as insensitive to the impact of industrial waste water or the impact-insensitive species.

There was noticeable shift in the dominance status for many oribatid species which may be conveniently considered as impact-sensitive species. Twentysix species (1 dominant, 4 subdominant and 21 rare) of the unpolluted site responded negatively to the impact of industrial waste water. *Scheloribates fimbriatoides*, which was dominant in the unpolluted site was rare in the polluted site. Three subdominant species in the unpolluted site turned into rare species in the polluted site whereas one subdominant species *(Sphaerochthonius* sp.) and 21 rare species of the unpolluted site were totally absent in the polluted site and therefore their responses were also considered to be negative one. This may logically lead to the assumption that the waste water some how or other made the habitat unfavouable for the existence of these species ultimately resulting into the simplification of the oribatid community as a whole in the polluted site.

Contrary to these, response pattern was positive for 8 species. Of these, 2 species viz., *Galumna flabellifera* which was subdominant and *Xylobates indicus* which was rare in the unpolluted site, became dominant in the polluted soil. Six 'rare' species, which were encountered only in the polluted site, were also considered to be exhibiting positive response since these were absent in the unpolluted site. Their presence in the polluted site is suggestive of their extraordinary capability to resist the impact of industrial waste water. Attainment of 'dominant' status by the two species was most probably due to reduction in the number of species and subsequent decrease in competition in the polluted site. On the other hand the 6 'rare' species of the polluted site were perhaps pioneer species in that area which were in the early state of colonization.

When the percentage deviation in abundance of three dominant impact sensitive species is compared (Table 1), it is seen that *Scheloribates fimbriatoides*

TABLE 1. Relative abundance, abundance and percentage deviation in abundance of three impact-sensitive dominant oribatid species.

Impact-sensitive dominant species	Relative abundance		Abundance		Percentage deviation in abundance
	UP	P	UP	P	
1. *Scheloribates fimbriatoides*	5.26	0.16	1.14	0.03	— 97.4
2. *Xylobates indicus*	0.43	9.00	0.09	2.01	+ 2133
3. *Galumna flabellifera*	2.25	11 56	0.49	2.58	+ 427

UP = Unpolluted site, P = Polluted site, + = increase, — = decrease.

suffered a 97.4% reduction in the abundance whereas *Xylobates indicus* and *Galumna flabellifera* experienced 2133% and 427% increase in the abundance. Therefore, these three species seem to have the potentiality to be used as a bio-indicator of environmental stress or pollution. The potentiality of soil oribatid species to act as bio-indicator of soil pollution has also been emphasized by VANEK (1973), DINDAL (1977) and KRIVOLUTSKY (1979).

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NATURAL ENEMIES OF RICE LEAF- AND PLANT-HOPPERS IN ANDHRA PRADESH*

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Intensive surveys in Andhra Pradesh resulted in the discovery of 10 egg-parasites, 7 nymphal-adult parasites, a hyperparasite and 2 predators of leaf- and plant-hopper pests of rice. Of these, the egg parasites, *Oligosita tachikawai* Yashiro and *Anagrus armatus (=columbi)* (Ashmead), and the nyphal-adult parasites *Gonatopus* spp. appear to be new records. Field data on the extent of parasitisation by key species are reported.

(Key words: natural enemies, rice hoppers)

Consequent on the serious outbreaks of the brown planthopper (BPH), *Nilaparvata lugens* (Stäl) in the early seventies and its rapid spread to newer areas in India, considerable attention is being paid to suitable control measures, including biological control. Natural enemies have been reported from Karnataka (MANJUNATH, 1978a, b; MANJUNATH *et al.*, 1978), and a few other regions of the country (PAWAR, 1975; SAMAL & MISRA, 1978), emphasising their role in suppressing the pest. The present surveys carried out in Hyderabad and other areas in Andhra Pradesh led to the discovery of 10 egg-parasites, 7 nymphal-adult parasites, a hyperparasite and 2 predators of leaf- and plant-hopper pests. These are listed in Table 1.

Among the egg parasites, *Anagrus* spp., and *Oligosita* spp., were predominant on planthoppers while *Gonatocerus* sp. and *Paracentrobia* on leafhoppers. Scelioniid or eulophid parasites were not obtained. *O. tachikawai* Yashiro is a new record while *A. armatus (=columbi* (Ashmead) recovered from Wast Godavari district appears to be new to India on the basis of earlier reports (MANJUNATH *et al.*, 1978; ANONYMOUS, 1978; CHANDRA, 1979; SUBBA RAO, 1983). Monitoring the population of egg parasites at Hyderabad revealed two peaks of occurrence *i. e*, March and August-September on planthopper eggs while three peaks, *i. e.*, October, December and April on leaf hopper eggs. During the crop season *(rabi* 1981), on an average 16.1 per cent of BPH eggs were found parasitised, of which *Oligosita* spp., accounted for 10.6 per cent. This is in contrast to the observation at Pantnagar where *Anagrus* sp., was reported as parasitising higher percentage of BPH eggs during *kharif* 1983 (ANONYMOUS, 1983). In our studies egg predation, mainly by the mirid bug *Cyrtorhinus lividipennis* Reut., resulted in higer percentage mortality (20.4 and 29.8) during *rabi* seasons of 1981 and 1982, respectively, than that due to egg parasites (16.1 and 1.4).

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TABLE 1. Natural enemies of rice leafhopper and planthopper pests of rice recorded from Andhra Pradesh, India.

Natural enemy species	Host
Egg parasites	
Hymenoptera : Mymaridae	
Anagrus sp.	BPH, WBPH
A. ?armatus (= columbi) (Perkins)	BPH, WBPH
A. flaveolus Waterhouse*	BPH, WBPH
A. optabilis (Perkins)	BPH, WBPH
Gonatocerus sp.	GLH
Mymar sp.*	BPH, WBPH
Hymenoptera : Trichogrammatidae	
Oligosita ?naias Gerault	BPH, WBPH
O. tachikawai Yashiro**	BPH, WBPH
O. yasumatsui Subba Rao & Viggiani**	BPH, WBPH
Paracentrobia andoi (Ishii)	GLH
Nymphal-adult parasites	
Hymenoptera : Dryinidae	
Gonatopus sp.	BPH, WBPH
?Gonatopus sp.	GLH
Gonatopodini	GLH
Neogonatopus sp.	BPH, WBPH
Diptera : Pipunculidae	
Pipunculus sp.	GLH?
Tomosvaryella sp.	GLH
Strepsiptera : Elenchidae	
Elenchus yasumatsui K & H*	BPH, WBPH
Hyperparasite	
Hymenoptera : Encyrtidae	
Agarwalencyrtus citri (Agarwal)	Pipunculid pupae
Egg and nymphal predators	
Heteroptera : Lygaeidae	
Cymodema basicornis Motsch	BPH, WBPH, GLH
Heteroptera : Miridae	
Trigonotylus doddi (Dist.)	BPH, WBPH, GLH

Source of identification: * — available keys; ** — Dr. Sudha Nagarkatti through Dr. Viggiani; rest from Commonwealth Institute of Entomology, London; BPH—Brown planthopper, *Nilaparvata lugens* (Stål); WBPH—White backed planthopper, *Sogatella furcifera* (Horv.) GLH—Green leafhoppers, *Nephotettix* spp.

The dryinid *Gonatopus* has not earlier been listed as attacking rice hoppers (MANJUNATH *et al.*, 1978a; CHIU, 1979) though related genera *viz., Pseudogonatopus* and *Haplogonatopus* are well known. Field studies during *kharif* 1981 indicated a total of 8.7 and 10.7 per cent parasitisation of BPH and white backed planthopper (WBPH) by dryinids; third and fourth instar nymphs recorded higher parasitisation (Table 2). During *kharif*, only 0.1 per cent of WBPH was attacked by the strepsipteran. During *rabi* seasons of 1982 and 1984 immigrating adults were found carrying parasites in them. On an average 2.8 and 10.0 per cent macropterous immigrating adults were parasitised by dryinids during these seasons, while 10 to 30 per cent by the strepsipteran during 1984.

Besides the above listed natural enemies, the common mirid (*C. lividipennis*), coccinellid (*Coccinella arcuata* L.) and spiders (*Lycosa pseudoannulata* B. & S. and *Tetragnatha* sp.) were also abundant in rice fields. Published information on the biology and biocontrol potential of the mirid predator (POPHALY *et al.*, 1978) and some of the egg and nymphal parasites (BENTUR *et al.*, 1982) are already available.

TABLE 2. Average parasitisation by dryinids at different nymphal instars and adults of brown planthopper (BPH) and white backed planthopper (WBPH) during *kharif* 1981 at DRR farm, Rajendranagar, Hyderabad.

Stage of the host	Average parasitisation (%)	
	BPH	WBPH
I & II Nymphal instars	0.8	0.3
III & IV Nymphal instars	3.4	4.6
V Nymphal instar	2.2	4.2
Adult	2.3	1.6
Total	8.7	10.7

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BRIEF COMMUNICATION

ROOT INFESTING APHIDS (HOMOPTERA : APHIDIDAE) FROM MANIPUR, NORTH EAST INDIA

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This paper reports 11 species of root infesting aphids in Manipur. These are distributed over 6 genera belonging to 2 subfamilies Aphidinae and Pemphiginae. Of these, *Sapaphis piri* is reported for the first time from North east India and 4 species, viz., *Rhopalosiphum rufiabdominalis*, *Geoica sikkimensis*, *Tetraneura kalimpongenesis* and *T. sikkimensis* are new records of Manipur.

(Key words: Taxonomy, root aphids, 11 species)

Raychaudhuri *et al.* (1978) while working on root infesting aphids from North east India, reported 7 species from Manipur. Similar work on the root infesting aphids in North east India was reported by Pal and Raychaudhuri (1978). Kumar (1973) also reported *Saphaphis piri* from North West Himalaya. The present study, based on survey during 1981-1982, reveals existence of more species. Thus, 11 species are known to infest roots of various plants in Manipur. These species are distributed over 6 genera belonging to 2 sub-families Aphidinae and Pemphiginae. Of these species viz. *Sapaphis piri* is reported for the first time from North east India and 4 species, viz., *Rhopalosiphum rufiabdominalis*, *Geoica sikkimensis*, *Tetraneura kalimpongenesis* and *T. sikkimensis* are new records of the State.

All the type materials are now deposited in the collection of Entomology laboratory, Department of Life Sciences, University of Manipur, India.

A list of recorded root aphid species together with their host plants is given below:

Aphid species	Host plant
Sub-family : Aphidinae	
1. *Rhopalosiphum rufiabdominalis* (Sasaki)	*Oryza sativa*, *Imperata cylindrica* *Paspalum* sp.
2. *Sapaphis piri* Matsumara	*Artemisia vulgaris*

(continued)

(continued Table)

Sub-family : Pemphiginae	
3. *Chaetogeoica graminiphaga* Raychaudhuri, Pal and Ghosh	*Echinochloa* sp.
4. *Chaetogeoica polychaeta* Raychaudhuri, Pal and Ghosh	*Microchlra* sp.
5. *Geoica lucifuga* (Zehntner)	*Kylinga* sp.
6. *Geoica sikkimensis* Raychaudhuri, Pal and Ghosh	*Carex* sp., *Echinochloa* sp.
7. *Tetraneura basui* Hille Ris Lambers	*Panicum paludosum, Echinochloa* sp., *Chrysopogon* sp., *Axonopus* sp., *Setaria* sp., *Polytoca* sp., *Hymenachne* sp.
8. *Tetraneura kalingpongenesls* Raychaudhuri, Pal and Ghosh	*Paspalum* sp., *Kylinga brevicola, Setaria* sp.
9. *Tetraneura nigriabdominalis* (Sasaki)	*Oryza sativa, Paspalum* sp., *Imperata cylindrica, Panicum* sp., *Isachne albens Callipidium* sp., *Chrysopogon* sp., *Axonopus* sp., *Setaria* sp.
10. *Tetraneura radicicola/yezoensis* group,	*Echinochloa* sp., *Imperata cylindrica, Microglogium* sp., *Eragrostis tremula, Chrysopogon* sp.
11. *Tetraneura sikkimensis* Raychaudhuri, Pal and Ghosh	*Imperata cylindrica, Setari* sp., *Microchloa* sp., *Eragrostis* sp., *Paspalum* sp.

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INVESTIGATIONS ON *TELENOMUS REMUS* NIXON AND *APANTELES MARGINIVENTRIS* CRESSON AGAINST *SPODOPTERA LITURA* (FABRICIUS) ON CABBAGE

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Spodoptera litura (Fabr.) is a sporadic pest on vegetables but some times a serious pest on cole crops like cauliflower, cabbage, etc,. in India. Field cage studies were conducted with two exotic parasites namely *Telenomus remus* Nixon (origin New Guinea) and *Apanteles marginiventris* Cress. (origin : West Indies) against *S. litura* on cabbage. The egg parasite, *T. remus* gave upto 100 per cent parasitism whereas *A. marginiventris* produced below 5 per cent larval parasitism of *S. litura* under caged conditions. It is inferred that *T. remus* could be exploited on large scale for the control of *S. litura* on cabbage.

(Key words: Telenomus remus, Apanteles marginiventris, Spodoptera litura, cabbage)

INTRODUCTION

Spodoptera litura (Fabr.) occurs sporadically in severe from on cole crops like cabbage, cauliflower, etc., in India (SINGH & BYAS, 1976; PANDEY, 1977; BATTU, 1977; BATTU & DILAWARI, 1978; RAJAMOHAN & JAYARAJ, 1978) and Philippines (MORALLOREJESUS & EROLES, 1979). This polyphagous pest is found on cabbage around Bangalore in endemic form. The natural enemy complex of *S. litura* is very low on cabbage and at times it appears as a serious pest. An egg parasite, *Telenomus remus* Nixon (Hymenoptera : Scelionidae) (Origin : New Guinea) and a larval parasite, *Apanteles marginiventris* Cresson (Hymenoptera : Braconidae) (Origin : West Indies) were obtained under the ICAR All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds for trials against *S. litura* in India. The present paper reports the performance of these two exotic parasites against *S. litura* on cabbage under field cage conditions.

MATERIALS AND METHODS

Multiplication of host and the parasites:

a) *S. litura:* Since large number of host insects are required for mass rearing of parasites, the larvae of *S. litura* were mass multiplied on artificial diet developed for *Heliothis armigera* (Hubn.) by NAGARKATTI & SATYAPRAKASH (1974). Both male and female moths were held together in a plastic container for mating and oviposition. An ordinary paper lining on all the sides was provided inside the container for the moths to lay eggs.

b) *T. remus:* The ordinary paper containing one day old egg masses of *S. litura* were cut and pasted on a 7cm × 2.5cm strip of paper. These were exposed to freshly emerged adults of *T.*

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remus for parasitization The adults of *T. remus* emerged 10–12 days after parasitization. After emergence, *T. remus* adults were held in the laboratory for 24 h to ensure mating before using them for field cage trials.

c) *A. marginiventris:* Males and females (3:1) of the parasite were released in a mating cage (10.5 cm × 9.5 cm × 7 cm) having wooden base, glass front (sliding) and clothed sides and top and kept in sunlight for a few minutes for mating. Three day old *Spodoptera* larvae held on castor leaves were exposed to 2 day old mated females of *A. marginiventris* for 24 h for parasitization. Afterwards all the larvae of *S. litura* were reared on artificial diet until the exit of the parasite larvae from the host body and their cocoon formation. To ensure matings on emergence the newly emerged females and one day old males of the parasite were held together for 24 h. Such mated females were then released in the field cage for observations.

OBSERVATIONS

The performance of the parasites was tested by releasing them in nylon field cages (1.8 m × 1.8 m × 1.8 m) erected on the cabbage crop raised during October, 1982 to January 1983. Each cage enclosed 15 plants. Since the natural incidence was low, artificial inoculation was carried out by stappling paper bits containing *S. litura* egg masses on either side of the leaves and at different position of the plant randomly.

T. remus: In the first trial 15 fresh egg masses of *S. litura* were fixed inside the cage and about 3000 adults of *T. remus* were released in the evening. Four days after parasite release the egg masses were collected from the field cage and kept in the laboratory for observation. All the 15 egg masses were found to be completely parasitized resulting in 100 per cent parasitism (Table 1). When 20 egg masses were offered to the same number of parasites in the second trial, 100 per cent parasitism was observed. Low (30–40 per cent) parasitism was observed in a trial where about 1000 adults of *T. remus* were released against 10 egg masses of *S. litura.* In all the trials no partial parasitism of egg mass was observed. All the adults emerged from the field parasitized egg masses were later identified as *T. remus.*

A. marginiventris: Three cages were erected and 10 egg masses were fixed at random in each cage. Three days after larvae have hatched 5 mated females of *A. marginiventris* were released in each cage. Five days after the release of parasites, the larvae of *S. litura* were collected from each cage and reared on artificial diet in the labortory for recovery of cocoons. The performance of *A. marginiventris* against the larvae of *S. litura* on cabbage is furnished in Table 2. Of the 90, 110 and 85 larvae collected from each cage, 4, 5 and 4 cocoons respectively were obtained. The per cent parasitism thus obtained was between 4.44 and 4.70. The adults emerged from the cocoons were identified as *A. marginiventris.*

DISCUSSION

As high as 100 per cent parasitism of *S. litura* by *T. remus* was obtained in the present study under caged conditions on cabbage field, when the egg mass and adult parasite ratio was 1:200 or 1:150. However, the per cent parasitism got adversely affected when the ratio was changed to 1:100. ALAM (1974) also reported that open field releases of *T. remus* in West Indies against *Spodoptera* spp. gave up to 85.7 per cent

TABLE 1. Field cage performance of *T. remus* against *S. litura* on cabbage.

Cage	No. of egg masses of *S. litura*	No. of parasites released	No. of egg masses parasitised	% parasitism
I	15	3000	15	100
II	20	3000	20	100
III	10	3000	10	100
IV	10	3000	10	100
V	10	1000	4	40
VI	10	1000	3	30

TABLE 2. Field cage performance of *A. marginiventris* against *S. litura* on cabbage.

Cage	No. of egg masses	No. of mated females released	No. of larvae recovered from the cage	No. of cocoons obtained	% parasitism
I	10	5	90	4	4.44
II	10	5	110	5	4.54
III	10	5	85	4	4.70

parasitism on sweet potato and 54.7 per cent on maize. Hence it is also worth to exploit this parasite on large scale open field releases against *S. litura* on cabbage wherever this pest occurs in severe from.

Due to the preponderance of males of *A. marginiventris*, in the laboratory culture large number of females could not be released. Though 5 females per cage were released, plenty of *S. litura* larvae were provided for the parasites to oviposit. In spite of the large population of host larvae available, the parasite did not do well under cabbage environment where it produced below 5 per cent parasitism. However, inoculative releases may be attempted to improve the natural enemy complex against the pest in the problem areas.

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BRIEF COMMUNICATION

CHANGES IN THE METABOLIC FUEL RESERVES OF THE V INSTAR *BOMBYX MORI* FOLLOWING ENDOSULFAN TREATMENT

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Administration of endosulfan (6, 7, 8, 9, 10, 10-hexachloro-1, 5, 5a, 6, 9, 9a-hexahydro-6, 9-methano-2, 4, 3-benzodioxathiepin, 3-oxide) along with mulberry leaves (12 to 15 microgram endosulfan larva) causes considerable changes in the fuel reserves of the fat body and haemolymph tissues. Both glycogen and acylglycerol contents of the fat body increased significantly with concomitant depletion of trehalose, free fatty acids and acylglycerol levels from the haemolymph at the prostration stage of poisoning. It is suggested that additional acylglycerol and glycogen that appeared in the fat body of the poisoned larva may be due to the rapid uptake by fat body and that these were from the haemolymph.
(Key words: endosulfan, fat body, hemolymph fuel reserves, silk worm, *Bombyx mori)*

Toxicity of insecticides on non-target organisms is now very well recognized. The primary site of action of most successful insecticide is the nervous system (MADDRELL, 1980). However, in recent years it has become clear that insecticides induce release of neurohormones from neuroendocrine tissues and consequent perturbation of normal physiological functions (SAMARANAYAKA, 1974; NORMAN, 1980; ORR & DOWNER, 1982). Endosulfan is widely used against a variety of agricultural pests which may affect non-target organisms as well. In the present study an attempt is made to evaluate the effect of endosulfan on the carbohydrate and lipid contents of fat body and haemolymph tissues of V instar silk worm *Bombyx mori*.

The technical grade endosulfan (Rallis India) was dissolved in known volume of acetone and applied to fresh mulberry leaves (20μg/leaf). Bivoltine NB_4 D_2 used in the present study were obtained from laboratory culture. Larva was allowed to feed on the treated leaves. Based on the leaf consumption, it was possible to calculate the amount of insecticide ingested by each larva. Generally each larva consumed about 12 to 15μg of endosulfan in four hours time. Control larvae were allowed to feed on the leaf treated with equal volume of acetone alone. Larvae fed on insecticide treated leaves exhibited sequences of behaviour patterns that can be used to determine the progression of poisoning. In the present study the larva undergoing prostration period which occurs 180 min following the insecticide treatment was used. The haemolymph was collected in prechilled centrifuge tube by cutting off the prothoracic appendages. After collecting the blood the larva was dissected under

icecold Ringer's solution. Fat body was collected from each larva separately. Both the tissues were used almost immediately for the determination of fuel reserves. Trehalose content of the haemolymph was determined according to the anthrone method of ROE (1955). The total glycogen content was estimated following the precipitation of glycogen from a saturated solution of sodium sulfate with ethanol. Glucose was used as reference standard. Tissue acylglycerol was extracted with isopropanol, hexane and sulfuric acid mixture (4:1:0.1, v/v). The extracted lipid was hydrolyzed and released glycerol was determined according to the procedure of GIEGEL *et al.* (1975). Free fatty acid content was determined according to the procedure of HOWORTH *et al.* (1966).

That endosulfan produces considerable changes in the metabolic flux of the fat body as well as of the haemolymph of V instar *B. mori* is very well seen from the present results (Tables 1 & 2). Both acylglycerol and glycogen content of the fat body increased significantly (Table 1) with concomitant depletion of trehalose, free fatty acids and acylglycerol contents from the haemolymph (Table 2) due to endosulfan treatment. Control larvae which received acetone alone did not reveal any appreciable changes in the metabolic reserves of fat body and hemolymph tissues. A similar disturbance due to insecticide treatment in the fuel reserves of fat body and haemolymph has been reported for locust (SAMARANAYAKA, 1974) and cockroach (ORR & DOWNER, 1981). The

TABLE 1. Effect of endosulfan on the glycogen and acylglycerol contents of fat body of the V instar *B. mori*.

	microgram / mg wet wt tissue		
Fuel reserve	Before treatment	Aetone treatment	Endosulfan treatment
Glycogen	3.6 ± 0.82*	2.65 ± 0.33	12.52 ± 2.32 (t = 4.39)
Acylglycerol	7.38 ± 0 93	8.68 ± 1.75	15.34 ± 1.55 (t = 4.845)

* Results indicate mean ± SEM of seven experiments.

TABLE 2. Influence of endosulfan on trehalose, acylglycerol and free fatty acid levels of haemolymph of V instar *B. mori*.

	microgram / 100 microliter blood		
Content	Before treatment	Acetone treatment	Endosulfan treatment
Trehalose	516.0 ± 11.0*	516.94 ± 22.0	163.7 ± 5.32 (t = 21.0)
Acylglycerol	1.32 ± 0 07	1.2 ± 0.09	0.77 ± 0.05 (t = 4.3)
Free fatty acid	6.0 ± 1.0	6.94 ± 2.0	3.7 ± 0 32 (t = 1.6)

* Results indicate mean ± SEM of seven experiments

results of the present study suggest that the additional acylglycerol and glycogen that appeared in the fat body may be due to the rapid uptake of fatty acids, acylglycerol and trehalose by fat body and that these were from the haemolymph.

Corpus cardiacum is an important source of neurohormone that regulates carbohydrate and lipid metabolism in insects (STEELE, 1976), and this neurohormonal organ has been identified as a probable site for the action of insecticide in mediating effects on metabolic reserves (SAMARANAYAKA, 1978). It is beleived from the present study that perhaps endosulfan causes indiscriminate release of neurohormone(s) which leads to the metabolic imbalance and eventual death of the insect.

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SEQUENTIAL SAMPLING PLAN FOR MANGO LEAF HOPPER, *IDIOSCOPUS CLYPEALIS* LETHIERRY

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A sequential plan for classifying infestation into light, moderate and severe, of the mango hopper, *Idioscopus clypealis* Lethierry has been worked out for adults and nymphs which followed a negative binomial distribution. The Operating Characteristic and Average Sample Number values were also worked out. The decision lines plotted would be useful as a ready reckoner to assess infestation classes in extensive surveys.

(Key words: sequential sampling plan, light moderate and severe infestations, adults, nymphs)

INTRODUCTION

The mango leaf hopper is the most serious pest of mango infesting mainly the panicles, causing great loss to mango production. The adults and nymphs suck the sap and retard normal panicle development causing eventual fruit drop. This pest is widely distributed in India and other parts of the world. Several chemical control measures are available and normally prophylactic measures are recommended irrespective of the hopper population in the field. For effective and timely control a knowledge of the severity of the pest in the orchard is an essential pre-requisite. Thus far, no sampling methodology is available for quick estimation of the pest status in an orchard or tract. For planning control strategies, it is desirable to have suitable sampling techniques which allow quick classification of hopper infestation at several sampling points. Broad classification such as light, moderate and severe are generally adequate for mapping infestation over large areas with sufficient number of well distributed sampling points. For the mango hopper, surveys conducted at the begninning of infestation may provide a means of forecasting the damage to be expected due to nymphal and adult feeding. A sequential plan, having no fixed sample size is well suited to such surveys and permits the classification of infestation level within predetermined levels of accuracy. With this as objective, a sequential sampling plan has been worked out for the mango leaf hopper.

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MATERIALS AND METHODS

In the present study the tree was taken as the main sampling unit taking into consideration inter-tree variation rather than intra-tree variation in hopper population. The nymphs and adults were sampled separately in the present study. The nymphs were counted by shaking them on to a one sq ft white ivory

card board in a prestandardized jerk method from ten panicles randomly selected from a tree. For the adults, sweep method using insect nets with thin linen bags through which adults can be easily counted was adopted, in five random sweeps per tree. The survey was restricted only to two varieties of mango viz., *Dashehari* and *Mallika* of the species, *Mangifera indica*. Ninety trees were sampled for nymphs and 35 trees for adults in different orchards of Lucknow district during 1982 and 1983. Based on the sample counts, negative binomial distributions using common K for nymphs and adults were fitted. Using common K, the sequential plans were worked out following OAKLAND (1950) and MORRIS (1954).

Next, infestation limits were set for the nymph and adult population which conformed approximately to the degree of damage done, based on preliminary observations of the authors and also on earlier records of various workers. However, as many variables are involved the infestation classes should not be accepted too literally, and should be modified as more and more records are available. It is pertinent to mention that this is the first attempt at a sequential sampling plan for the mango hopper. Infestation classes used in the present study were as follows:

Infestation	Nymphs/panicle/tree	Adults Sweep/tree
Light	4 or less	5 or less
Moderate	Between 10 and 25	Between 10 and 20
Severe	More than 50	More than 40

Based on the above infestation classes, alternative hypotheses were set up and the acceptance and rejection lines were calculated and plotted. Further, Operating Characteristic values (OC) and Average Sample Number (ASN) were worked out.

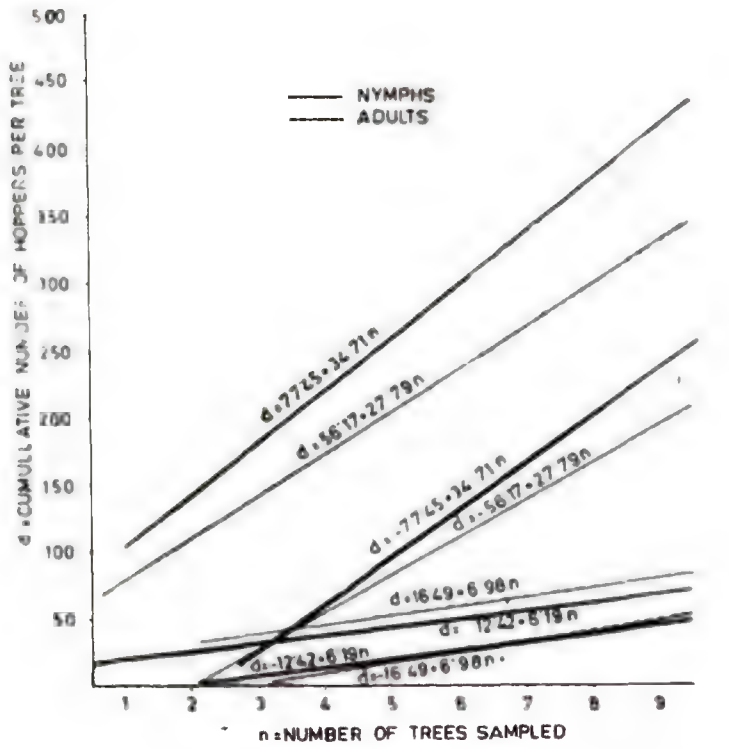

Fig. The acceptance and rejection lines for nymphs and adults

TABLE 1. The distribution constants under H_0 and H_1 (alternative hypotheses)

	Nymphs				Adults			
	Light (H_0)	Moderate (H_1)	Moderate (H_0)	Severe (H_1)	Light (H_0)	Moderate (H_1)	Moderate (H_0)	Severe (H_1)
K	1.4814				1.6620			
Mean Kp	4	10	25	50	5	10	20	40
$p = \frac{Kp}{k}$	2.7001	6.7504	16.8759	33.7518	3.0084	6.0168	12.0337	24.0674
$q = 1 - p$	3.7001	7.7504	17.8759	34.7518	4.0084	7.0168	13.0337	25.0674
Variance Kpq	14.8008	77.5040	446.8975	1737.5900	20.0420	70.1680	260.6740	1002.6960

RESULTS AND DISCUSSION

When common K was calculated, it was found to be 1.4814 and 1.6620 for nymphs and adults respectively, thereby showing aggregation. The values of the distribution constants both for nymphs and adults are presented in Table 1. For the hopper survey in the present study, the Type I (α) and Type II (β) errors were set at 10%.

The decision equations for light versus moderate and moderate versus severe for nymphs and adults are as follows:

	Nymphs	Adults
Light *vs* Moderate	$d = 6.19n \pm 12.42$	$d = 6.98n \pm 16.49$
Moderate *vs* severe	$d = 34.71n \pm 77.45$	$d = 27.79n \pm 56.17$

Where n is the number of trees to be sampled and d is the cumulative number of hoppers. The equations are plotted in Fig. 1 for rating infestation classes.

Ths cumulative hopper number for the samples trees for use in the field conditions known as sequential table is given in Table 2.

From Table 2, it can be inferred that at least 3 trees need to be sampled with a cumulative hopper count less than 7 for it to be classified under light infestation class. If the hopper count on the first tree is 19 or more but less than 113, it will be classified as moderate and more than 113 will be classified as severe. Likewise, the same pattern holds good for adults.

TABLE 2. Sequential table based on the decision lines.

Tree	Nymphs					Adults				
	Light *versus* Moderate			Moderate *versus* Severe		Light *versus* Moderate			Moderate *versus* Severe	
	LIGHT ZONE	MODERATE ZONE	SEVERE ZONE	LIGHT ZONE	MODERATE ZONE	SEVERE ZONE	LIGHT ZONE	MODERATE ZONE	SEVERE ZONE	LIGHT ZONE	MODERATE ZONE	SEVERE ZONE
1	0	19		0	113		0	24		0	84	
2	0	25		0	147		0	31		0	112	
3	7	31		27	182		5	38		28	140	
4	13	38		62	217		12	45		55	168	
5	19	44		97	251		19	52		83	196	
6	25	50		131	286		26	59		111	223	
7	31	56		166	321		33	66		139	251	
8	38	62		201	356		40	73		167	279	
9	44	69		235	390		47	80		194	307	
10	50	75		270	425		54	87		222	333	

TABLE 3. Operating Characteristic and Average Sample Number Values.

	Nymphs								Adults							
	Light *versus* Moderate				Moderate *versus* Severe				Light *versus* Moderate				Moderate *versus* Severe			
h	P	Kp	L (p)	E (n)	P	Kp	L (p)	E (n)	P	Kp	L (p)	E (n)	P	Kp	L (p)	E (n)
α	0	0	1.00	2.00	0	0	1.00	2.23	0	0	1.00	2.36	0	0	1.00	
1	2.70	4.00	0.90	4.54	16.92	25.07	0.90	14.46	3.01	5.00	0.90	6.66	12.03	19.99	0.90	
$\frac{1}{2}$	3.34	4.95	0.75	5.00	19.85	29.41	0.75	7.30	3.54	5.88	0.75	7.49	14.12	23.46	0.75	
1/4	3.73	5.52	0.63	4.82	21.57	31.95	0.63	7.29	3.86	6.42	0.63	7.66	15.35	25.51	0.63	
−1/4	4.69	6.94	0.37	4.31	25.65	38.00	0.37	6.12	4.59	7.61	0.37	6.80	18.25	30.33	0.37	
$-\frac{1}{2}$	5.28	7.82	0.25	3.81	28.07	41.58	0.25	5.64	5.03	8.36	0.25	5.97	19.97	33.19	0.25	
−1	6.75	10.00	0.10	2.61	33.84	50.13	0.10	4.01	6.02	10.01	0.10	4.35	24.02	39.92	0.10	
−3/2	8.72	12.91	0.04	1.70	41.16	60.97	0.04	2.71	7.26	12.07	0.04	2.98	29.26	48.63	0.04	
$-\infty$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

The operating characteristic values which give probability L(p) for reaching a correct decision for a range of population means for both adults and nymphs are given in Table 3. The probability of classifying the mean of 4.00 and 25 hoppers into light and moderate zones, respectively, is 0.90 and of classifying a mean of 10 and 50 hoppers into light and moderate zones respectively, is 0.1. Similarly, the probability of classifying 10 adults as light or 40 adults as moderate infestation is 0.10.

The average Sample Number Values [E(u)] shown in Table 3 can be used to predict the average number of trees to be sampled under different sequential plans. For example to get a mean of 7 hoppers at least 5 trees are to be sampled under light *versus* moderate infestation whereas the same number of trees are needed to get a mean of 51 under moderate *versus* sever infestation class.

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APHIDOPHAGOUS COCCINELLIDS OF NORTH EASTERN INDIA : MANIPUR-1

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A preliminary survey of the aphidophagous coccinellids of Manipur State, a north-eastern State of India, was carried out during the period of 1982-1983. Both larval and adult coccinellids were collected from different habitats of various aphid species in certain places of the state. A total of 20 species belonging to 14 genera were encountered during the survey.

(Key words: aphidophagous coccinellids)

Agarwala *et al.* (1980) reported 5 species of coccinellids predating on aphids from the state of Manipur, a north eastern state of India. Although similar studies on aphidophagous coccinellids with regard to their availability and distribution in most of the north eastern states of India were reported by Raychaudhuri *et al.* (1978, 1979), Agarwala *et al.* (1981), and Agarwala *et al.* (1983), these altogether reported 72 species of aphidophagous coccinellids from India so far.

Scanty information on the distribution of various aphidophagous coccinellid species in the state is available. The present communication is the result of preliminary survey of certain areas of Manipur for the occurrence and distribution of aphidophagous coccinellid species during the period of 1982–1983. All the materials reported in the present communication except *Vernia* sp. and *Scymnus* sp. of Agarwala *et al.* (1980), are in the collection of Entomology Laboratory, Department of Life Sciences, Manipur University, Canchipur.

The present paper includes a total number of 20 species belonging to 14 genera, and their aphid host/prey, host plant, place/locality, altitude, date and remarks are provided in Table 1.

Acknowledgements: The authors are thankful to the Head of Life Sciences Department, Manipur University, Canchipur for laboratory facilities and to Dr. A. P. KAPUR, the former Director, Zoological Survey of India, Calcutta for providing the opportunities to study some of the materials in their collection.

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TABLE I. List of predators with their host/prey, host plant, locality, date, altitude and remarks.

Name of the predator	Host/prey species	Host plant	Locality, date & altitude	Remarks
1. *Brumoides suturalis* (Fabricius) Predatory stage-adult	*Acrythosiphum pisum* (Harris)	*Lathyrus sativus*	Chingmeirong (18. iv. 1982; c 785 m)	Rarely occur
2. *Aiolocaria dodecaspilota* (Hope) Ps.– adult	*Tuberculatus indicus* Ghosh	*Quercus serrata*	Chingmeirong (12. x. 1983; c 785 m)	Occasionally found in oak farms.
3. *Calvia trilochana* Kapur Ps.– adults	*Tuberculatus indicus* Ghosh	*Quercus dealbata*	Phayang (19. xi. 1982; c 900-950 m)	Seems to be casual predator of aphids
	Cervaphis quercus Takahashi	–do–	–do–	
4. *Coccinella transversalis* Fabricius Ps– grub & adult	*Tuberculatus indicus* Ghosh	*Quercus serrata*	Chingmeirong (17. vi. 1982; c 785 m)	Most common predator of aphids
	Cervaphis quercus Takahashi	–do–	Chingmeirong (25. ix. 1983; c 785 m)	
	Aphis gossypii Glover	*Ageratum conyzoides*	Huikap (2. x. 1983; c 755 m)	
	Aphis craccivora Koch	*Dolichos lablab*	Uripok (20. ix. 1983; c 785 m)	
5. *Coccinella septempunctata* Linnaeus Ps.– adult	*Tuberculatus indicus* Ghosh	*Quercus serrata*	Chingmeirong (17. vi. 1982; c 785 m)	Most common predator of aphids
	Aphis gossypii Glover	*Ageratum conyzoides*	Haobam Marak (17 i. 1982; c 785 m)	
	Aphis craccivora Koch	*Smithia sensitiva*	Uripok (20.iv.1982; c 785 m)	
		Dolichos lablab	Awangkhunou (12. xii. 1982)	
	Hyadaphis coriandri (Das)	*Coriandrum sativum*	Haobam Marak (23 ix. 1983; c 785 m)	
	Lipaphis erysimi Kaltenback	*Brassica napus*	Kanto sabal (13. xi. 1983; c 785 m)	
	Acrythosiphon pisum (Harris)	*Lathyrus sativus*	Top Awang Leikai (25.xii.1983; c 785 m)	
6. *Oenopia kirbyi* Mulsant Ps.– adult	*Tuberculatus indicus* (Ghosh)	*Quercus serrata*	Chingmeirong (25. xii. 1983; c 785 m)	A common predator of aphid
	Aphis gossypii Glover	*Duranta repens*	Canchipur (15.xi. 1983; c 785 m)	

(Continued)

(Continued Table 1)

Name of the predator	Host prey species	Host plant	Locality, date & altitude	Remarks
7. *Oinopia luteopustulata* Mulsant Ps.-adult	*Aphis gossypii* Glover	*Duranta repens*	Chingmeirong (29. ii. 1983; c 785 m)	A common predator of aphid
		Eupatorium odoratum	Jiribam (18.xi. 1982; c 100 m)	
		Gynura lycopersifolia	Khurkhul (27.xi. 1983; c 795 m)	
	Tuberculatus indicus Ghosh	*Quercus serrata*	Chingmeirong (10. x. 1983; c 785 m)	
8. *Oinopia quadripunctata* Kapur Ps.- adult	*Aphis gossypii* Glover	*Duranta repens*	Chingmeirong (20. xi. 1982; c 785 m)	Most common predator of aphids
	Tuberculatus indicus Ghosh	*Quercus serrata*	Sekami (20.xi. 1982; c 785 m)	
	Aiceona litseae Basu & Hille Ris Lambers	*Litsea polyantha*	Canchipur 28.iii. 1983; c 785 m)	
9. *Gyrocaria sauzeti* (Mulsant) Ps.- adult	*Aphis gossypii* Glover	*Eupatorium odoratum*	Singda Dam (10. x.1983; c 900 m)	Rarely occur
10. *Gyrocaria sexareata* (Mulsant) Ps.- adult	*Brachycaudus helichrysi* (Kaltenback)	*Clerodendron* sp.	Ukhrul (13.v.1978; c 2000 m)	Commonly found in orchards
	Shinji pteridofoliae (Shinji)	Unidentified fern	Lamlang (12. v. 1978; c 1600 m)	
11. *Spilocaria bissellata* (Mulsant) Ps.- grub & adult	*Aphis gossypii* Glover	*Ageratum conyzoides*	Chingmeirong (25. ix. 1983; c 785 m)	Occur generally in groups
		Gynura lycopersifolia	Huikap (27. xi. 1983; c 755 m)	
12. *Lemnia saucia* (Mulsant) Ps. grub and adult	*Aphis gossypii* Glover	*Luffa cylindrica*	Lamphel pat (27. ii. 1982; c 755 m)	Most prevalent among *A. gossypii* of *L. cylindrica*
	Aphis craccivora Koch	*Smithia sensitiva*	Haobam Marak (27 ii. 1982; c 785 m)	
	Rhopalosiphum maidis (Fitch)	*Zea mays*	Lamphel pat (27. ii. 1982; c 785 m)	
	Melanaphis donacis (Passerini)	*Arundo donax*	Uripok (25.ix 1983; c 785 m)	
13. *Harmonia octomaculata* (Fabricius)	*Tuberculatus indicus* Ghosh	*Quercus serrata*	Chingmeirong (19. vii. 1982; c 785 m)	Rarely occur

(Continued)

(Continued Table 1)

Name of the predator	Host prey species	Host plant	Locality, date & altitude	Remarks
Ps.- grub and adult	*Aphis gossypii* Glover	*Luffa cylindrica*	Torongthel (2.xi. 1983; c 755 m)	
	Aiceona litseae Basu & Hilli Ris Lambers	*Litsea polyentha*	Canchipur (2. v. 1982; c 785 m)	
14. *Harmonia dimidiata* (Fabricius)	*Tuberculatus indicus* Ghosh	*Quercus serrata*	Chingmeirong (19. vii. 1982; c 785 m)	Most common in the oak forest
Ps.- grub and adult	*Aphis gossypii* Glover	*Sesamum indicum*	Uripok (12. iv. 1982; c 785 m)	
	Aiceona litseae Basu & Hilli Ris Lambers	*Litsea polyantha*	Canchipur (2. v. 1982; c 785 m)	
15. *Synonycha grandis* (Thunberg)	*Aphis craccivora* Koch	*Dolicos lablab*	Uripok (12. iv. 1982; c 785 m)	The most gregarious aphid predator
Ps.-grub and adult.	*Aphis gossypii* Glover	*Abelmoschus esculentus*	Haobam Marak (29 ii. 1982; c 785 m)	
	Tuberculatus indicus Ghosh	*Quercus serrata*	Phouljang (19. xi. 1982; c 765 m)	
16. *Callicaria superba* Mulsant	*Aiceona litseae* Basu & Hilli Ris Lambers	*Litsea polyantha*	Canchipur (2. v. 1982; c 785 m)	One of the most gregarious aphid predator
	Tuberculatus indicus Ghosh	*Quercus serrata*	Chingmeirong (13. xi. 1983; c 785 m)	
	Aphis gossypii Glover	*Eupatorium odoratum*	Samphejang (18. xi. 1982; c 1300 m)	
17. *Menochilus sexmaculatus* (Fabricius)	*Aphis gossypii*	*Solanum melongena*	Haobam Marak (12 viii. 1982; c 785 m)	Most common predator of aphids
		Luffa cylindrica	Lamphelpat (20. x. 1983; c 785 m)	
	Aphis craccivora Koch	*Dolicos lablab*	Uripok (25. vii. 1983; c 785 m)	
		Smithia sensitiva	Haobam Marak (25 vii.1983; c 785 m)	
	Acrythosiphum pisum (Harris)	*Lathyrus sativus*	Chingmeirong (24. vii. 1982; c 785 m)	
	Melanaphis donacis (Passerini)	*Arundo donax*	Uripok (25. ix. 1983); c 785 m)	
18. *Harmonia eucharis* (Mulsant)	*Tuberculatus indicus* Ghosh	*Quercus serrata*	Chingmeirong (14. vi. 1982; c 785 m)	Most prevalent n the coniferous forests
Ps.- grub and adult	*Cervaphis quercus* Takahashi	-do-	Chingmeirong (17. vi. 1983; c 785 m)	

(Continued)

(Continued Table 1)

Name of the predator	Host prey species	Host plant	Locality date & altitude	Remarks
19. *Scymnus* sp.	*Taoia indica* (Ghosh and Raychaudhuri)	*Alnus nepalensis*	Mao (19. v. 1978; c 2400 m)	Agarwala *et al.* (1980) recorded this predator from Manipur
Ps.– adult				
20. *Varania* sp.	*Eutrichosiphum taoi* Ghosh, Basu and Raychaudhuri	*Quercus serrata*	Ukhrul (13.v.1978; c 2000 m)	This predator also has been reported by Agarwala *et al.* (1980) from Manipur
Ps.– adult				

(Homoptera : Aphididae) in North east India. IV. Twelve Coleopteran and two Dipteran predators of aphids from Sikkim. *Entomon*, **6** (3), 207—209.

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SOME ECOLOGICAL OBSERVATIONS ON EAR-CUTTING CATERPILLARS (*MYTHIMNA* SPP.) INFESTING PADDY IN TRIPURA

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Two species of ear-cutting caterpillars, *viz. Mythimna separata* and *M. albistigma* are reported for the first time as sporadic but serious pests of 'aman' paddy from Tripura. Local varieties of paddy were found to be more susceptible than the high-yielding ones. The intensity of attack was observed more in low land valleys. The incidence on paddy was noticed during October—November The total life cycle of the pest, studied at 20 ± 2°C, ranged from 30 to 36 days.

(Key words: Mythimna separata, M. albistigma, ear-cutting caterpillars, 'aman' paddy)

Rice is the most important staple food in Tripura. One of the most important causes of low yield of paddy in the state is the damage caused by a number of insect pests which thrive well due to prevalence of moderate to high temperature (20 to 28°C) and high relative humidity (70 to 95 per cent) during most part of the year. No published research work on ecological aspects of agricultural insect-pests in general and of paddy pests in particular is available. The only reference available on insect-pests of paddy crop in Tripura is of GANGULY & GHOSH (1961) who recorded the names of insect-pests.

In India nine species of *Mythimna*, commonly known as rice ear-cutting caterpillars and paddy army worms, have several synonyms and have at times been misidentified (GHAI *et al.*, 1979). In spite of their status as important pests of paddy all over India, they have not received serious attention except preliminary notes on their occurrence (FLETCHER, 1919; RAMAKRISHNA AYYAR, 1963; NAIR, 1975). From Tripura no published information is available on this pest. Therefore, an investigation was taken up during 1981—1983 and the results are presented in the following pages.

Ear-cutting caterpillars as pests of paddy in Tripura came to be known for the first time in 1959 when they appeared in epidemic form and resulted in almost total loss of winter paddy crop in low land valleys. The second epidemic recorded was in 1963 in the same areas and caused serious economic loss. Since then the pest has been observed to be of regular occurrence.

Out of three crops raised a year, 'aman' paddy which is sown during August—September and harvested during

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November—December was observed to be exclusively attacked by *Mythimna* spp. (Lepidoptera : Noctuidae). A survey of the infested areas revealed presence of two species, *viz. M. separata* Wlk., and *M. albistigma* Moore. Out of the two, *M. separata* was recorded to be the more common one.

The infested areas were confined to valley regions of the state and their numbers were particularly high in Belonia, Khwai, Kailasahar and Dharmanagar Sub-divisions. The percentage of ear damaged varied from 5 to 8 per cent in upland valleys and 15 to 20 per cent in lowland valleys. Healthy plants were observed to be more severely attacked than the sickly ones. A varietal preference recorded under field conditions (Table 1) revealed that local (*Nagirasail*, *Lathisail*) and exotic improved (*Pyjam*) were found to be significantly more susceptible than the high yielding varieties (*IR-8*, *Jaya* and *IET-1444*). The incidence was noticed invariably in the third/fourth week of October and continued till late November. Outbreak of the pest occurred soon after heavy rains and floods followed by a dry spell of weather.

TABLE 1. Varietal susceptibility of paddy to *Mythimna* spp. in Sadar sub-division, Tripura, West during 1981.

Variety	Percentage of ear damaged
Nagirasail	5.2
Lathisail	6.1
Pyjam	5.5
IR-8	3.2
Jaya	2.0
IET-1444	2.8
CD at $P = 0.05$	1.192

The earlier larval instars confined themselves to eating only part of the leaves leading to skeletonisation of leaves while the later instars ate the whole leaves. The last instar (6th) larvae climbed up to earheads and cut off emerging panicles from the peduncle and in this way they caused most serious loss to the crop. The caterpillars shunned bright sunlight and took shelter inside cracks and crevices. The larvae were observed to be active from dusk to early hours of the day. Besides rice, they were also found feeding on maize, beans and grasses although their population was always very low. No incidence of the pest was recorded in autumn and summer rice crops.

The life cycle of *Mythimna separata* Wlk. was studied under laboratory conditions at 20 ± 2°C. The caterpillars were collected from the field and were released on the potted plants kept in cages. The newly emerged moths were utilized as a starting point for conducting life cycle studies.

Moths with fuscous brown abdomen, pale hindwings and red brown forewings measured 40 to 45 mm in wing-expanse. Females were slightly larger than the males and outnumbered the males (1.4:1). The longevity of males was shorter (3 to 4 days) than the females (6 to 7 days). Provision of five per cent glucose solution did not change their life span.

Moths emerged mostly during night and were attracted towards light. Copulation took place 12 to 18 hours after their emergence and lasted 25 to

35 minutes. Oviposition started within 24 hours after mating and continued for 3 to 5 days. The maximum number of eggs were laid on the second day of oviposition (60.5%). Number of eggs laid by each female varied from 256 to 400. Shining white, spherical with fine reticulations, eggs were laid in rows or in masses of 25 to 90 on the under surface of leaves (90 2 per cent) and remaining between the leaf sheath and stem. Only rarely the eggs were laid on the wire mesh of the cage. The percentage of hatching varied from 65 to 82. The egg stage lasted 3 to 5 days.

The newly-hatched larvae started nibbling leaves. Six larval instars were noticed which occupied 20 to 22 days. The full grown larvae were pale brown or dark with a brown head and 4 longitudinal stripes : a median dark brown line and two dark brown and one white lateral stripes. Pupation took place inside the soil in an earthen cell. From field some pupae were collected from leaf sheath also. The pupal period varied from 7 to 9 days.

One complete life cycle, from laying of eggs to the emergence of adults occupied 30 to 36 days.

Acknowledgements: The authors are thankful to the Director of the Centre for providing laboratory facilities. Thanks are also due to the Director, Zoological Survey of India, Calcutta for identifying the species.

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PREDATORS AND PARASITES OF APHIDS (HOMOPTERA: APHIDIDAE) FROM NORTH WEST HIMALAYA: TEN SPECIES OF SYRPHIDS (DIPTERAS : SYRPHIDAE) FROM GARHWAL RANGE

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The present paper reports 10 species of syrphids as predator of 34 species of aphids infesting 30 different host plants. Among them, *Metasyrphus latifasciatus* (Macq) and *Syrphus fulvifacis* Brun. are recorded as aphidophagous species for the first time in India. It has been observed that herbaceous prey-habitats are mostly preferred by all the syrphid species. The syrphid activity is extended over a period of March to October with a peak in June, which is further related to availability of prey aphids.

(Key words: aphidophagous syrphid, Garhwal Himalaya, prey records, habitat, season)

The aphidophagous syrphid fauna is very poorly represented from Garhwal range of north western Himalayas. The only account so far available is from CIBC, Indian Station (Rao, 1969) where four syrphid species *viz.*, *Epistrophe griseocincta* (Brun.), *Metasyrphus confrater* (Wied.), *Paragus serratus* F. and *P. verburyensis* Stuck, predating four aphid species *viz.*, *Aphis craccivora, A. gossypii, A. fabae solanella* and *Macrosiphoniella sanborni* were recorded from the foot hills of Dehradun.

The present paper reports the preliminary account of 10 species of Syrphidae under subfamily Milesiinae distributed over three tribes *viz.*, Melanostomatini, Paragini and Syrphini. Out of these 2 species *viz.*, *Metasyrphus latifasciatus* (Macq.) and *Syrphus fulvifacis* Brun. reported as aphidophagous species for the first time from India.

All the syrphid materials as well as the aphid hosts are in the collection of Biosystematics Research Unit, Department of Zoology, University of Kalyani.

For obtaining adult specimens, syrphid larvae and sometimes eggs were reared along with aphid colonies in plastic containers, the open mouth of which were tied with thick mesh nylon cloth, at the field station or during trekking in the year 1982 and 1983. The dried plant parts were replaced daily with fresh ones. The host plant (kept in herbaria) and aphid species for each sample afterwards were determined. Syrphid samples were subsequently identified.

(Host plants of aphids are cited in parenthesis)

Tribe : Melanostomatini

1. Melanostoma orientale (Wied.)

Prey aphids: *Aphis clematidis simlaensis (Clematis buchaniana); Brevicoryne brassicae (Brassica juncea, B. oleracea); Rhopalosiphum maidis (Triticum vulgare).*

Season : May–July

Habitat : Crop field and Road-side herbage.

Tribe: Paragini.

2. Paragus tibialis (Fallen)

Prey apids: *Aphis clematidis simlaensis (Clematis buchaniana); Aphis fabae (Rumex nepalensis); Capitophorus formosartemisiae (Artemisia vulgaris); Eriosoma lanigerum (Pyrus malus).*

Season: June September.

Habitat: Orchard, Garden, Roadside herbage.

Tribe: Syrphini

3. Betasyrphus serrarius (Wied.)

Prey aphids: *Hyperomyzus carduellinus (Sonchus arvensis); Macrosiphum rosae, M. (Sitobion) rosaeiformis (Rosa* spp.); *Myzus dycei (Urtica dioica); Myzus sorbi (Sorberia tomentosa); Uroleucon sonchi (Sonchus arvensis).*

Season: May–July.

Habitat: Garden, Roadside herbage.

4. Episyrphus balteatus (de Geer)

Prey aphids: *Aphis kurosawai (Artemisia vulgaris); Aphis spiraecola (Solanum nigrum); Brachycaudus helichrysi (Anaphalis marginata, Erigeron bonariensis, Prunus amygdalus); Brevicoryne brassica (Brassica juncea, B. oleracea); Epipemphigus imaicus (Populus ciliate); Eriosoma lanigerum (Pyrus malus); Hayhurstia atriplicis (Chenopodium album); Hyalopterus pruni (Prunus persica); Macrosiphum rosae (Rosa* sp.); *M (Sitobion) miscanthi (Triticum vulgare), Melanaphis* sp. *(Pyrus pashia); Myzus dycei (Urtica dioica); Myzus persicae (Solanum tuberosum); Prociphilus* sp. *(Lonicera* sp.); *Shinjia pteridifoliae (Pteris* sp.); *Toxoptera citricidus (Citrus* sp.).

Season: March to October,

Habitat: Crop field, Orchard, Garden, Roadside herbage.

5. Ischiodon scutellaris (Fab.)

Prey aphids: *Aphis craccivora (Vicia fabe); A gossypii (Cucumis* sp.); *A ruborum (Rubus ellipticus); A. verbasci (Verbascum thapus); Brevicoryne brassicae (Brassica juncea, B oleracea, Raphanus sativus); Capitophorus formosartemisiae (Artemisia vulgaris); Diphorodon cannabis (Cannabis sativa); Macrosiphum (Sitobion) miscanthi (Triticum vulgare); Myzus persicae (Solanum tuberosum); M. sorbi (Sorberia tomentosa).*

Season: March–September.

Habitat: Crop field, Garden, Roadside herbage.

6. Metasyrphus latifasciatus (Macq.)

Prey aphids: *Chaitophorus kapuri (Populus ciliata); Macrosiphoniella pseudoartemisiae (Artemisia vulgaris); Macrosiphum rosae, M. (Sitobion) rosaeiformis (Rosa* spp.).

Season: July–October

Habitat: Roadside tree, Garden, herbage.

7. Metasyrphus confrater (Wied.)

Prey aphids: *Brachycaudus helichrysi (prunus persica, P. amygdalus); Epipemphigus imaicus (Populus ciliata); Eriosoma lanigerum (Pyrus malus); Lachnus* sp. *(Salix* sp.); *Liosomaphis himalayensis (Berberis* sp.); *Macrosiphoniella pseudoartemisiae (Artemisia vulagris); Myzus dycei*

(Urtica dioica); Myzus sorbi (Sorberia tomentosa); Procihilus sp. *(Lonicera* sp.).

Season: June–October.

Habitat: Orchard tree, Garden, Roadside herbage.

8. Metasyrphus corollae (Fab.)

Prey aphids: *Brachycaudus helichrysi (Prunus persica); Brevicoryne brassicae (Brassica juncea, B. oleracea); Eriosoma lanigerum (Pyrus malus); Hyperomyzus carduelinus (Sonchus oleraceus); Myzus dycei (Urtica dioica).*

Season: April–June.

Habitat: Orchard, Garden, Roadside herbage.

9. Sphaerophoria scripeta (L.)

Prey aphids: *Brevicoryne brassicae (Brassica juncea); Liosomaphis himalayensis (Berberis asiaticum); Macrosiphum rosae (Rosa* sp.); *M. (Sitobion) miscanthi (Triticum vulgare); Myzus persicae (Solanum tuberosum).*

Season: April–June.

Habitat: Crop field, Roadside herbage.

10. Syrphus fulvifacis (Brun.)

Prey aphids: *Brevicoryne brassicae (Brassica juncea); Macrosiphoniella pseudoartemisiae (Artemisia vulgaris); Macrosiphum rosae, M. (Sitobion) rosaeiformis (Rosa* spp.).

Season: August–October.

Habitat: Crop field, Garden, Road side herbage.

It is difficult to predict any definite pattern of distribution, seasonal activities and host association of syrphid fauna in the area from such a small collection. Even then it is apparent from the available data that the peak period of activity is during June although these flies are found from March to October. As regards the habitats, they prefer prey aphids infesting mostly herbs. Out of the 10 syrphids, only *Episyrphus balteatus* has been recorded to feed maximum (16) aphid species.

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NEW SPECIES OF *BUSONIOMIMUS* AND *IDIOSCOPUS* (HOMOPTERA CICADELLIDAE : IDIOCERINAE) BREEDING ON MANGO IN SOUTH INDIA

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Busoniomimus manjunathi sp nov (from Yellapur and Hebri, Karnataka) *Idioscopus anasuyae* sp. nov. and *Idioscopus jayashriae* sp. nov. (both from Mangalore and Kodyamalai, Karnataka) are described and illustrated. These were found breeding on mango *(Mangifera indica* Linnaeus, Anacardiaceae) along with *I. clypealis* (Lethierry), *I. decoratus* viraktamath, *I. nagpurensis* (Pruthi) and *I. spectabilis* Viraktamath.

(Key words: Busoniomimus, Idioscopus, new species, leafhoppers breeding on mango)

Four species of idiocerine leafhoppers namely, *Amritodus atkinsoni* (Lethierry), *A. brevistylus* Viraktamath, *Idioscopus clypealis* (Lethierry), and *I. niveosparsus* (Lethierry) are considered as the major pests of mango *(Mangifera indica* Linnaeus, Anacardiaceae) in the Oriental Region (Gangolly *et al.*, 1957; Singh, 1968; Viraktamath, 1976). Ahmed *et al.* (1980) described three new species of Idiocerinae breeding on mango namely, *Amritodus saeedi*, *Idioscopus freytagi* and *I. karachiensis*. In this paper three new species of Idiocerinae breeding on mango along with *I. clypealis*, *I. decoratus* Viraktamath, *I. nagpurensis* (Pruthi) and *I. spectabilis* Viraktamath are described and illustrated.

The holotypes and paratypes of the new species are deposited in the Department of Entomology, University of Agricultural Sciences, Bangalore. One male and one female paratype each will be deposited in the Department of Zoology, Agricultural Engineering Institute, Raichur (India); Division of Entomology, Indian Agricultural Research Institute, New Delhi; Zoological Survey of India, Calcutta (India) and the British Museum (Natural History), London, U. K.

Busoniomimus manjunathi sp. nov. (Figs 1–15)

Vertex, pronotum and scutellum ochraceous brown. Two round spots on upper part of face partially visible in dorsal aspect, a large spot on each mesopleuron, two oval spots on disc and basal angles of scutellum (often brownish in males), black. Eye either grey with lateral dark spot or largely dark brown. Ocelli surrounded by dark brown. Forewing brown, basal 2/3 of costa dark brown with anterior margin often yellow. Leg ochraceous, distal transverse row of spines of hind tibia and tarsus reddish: claws brown.

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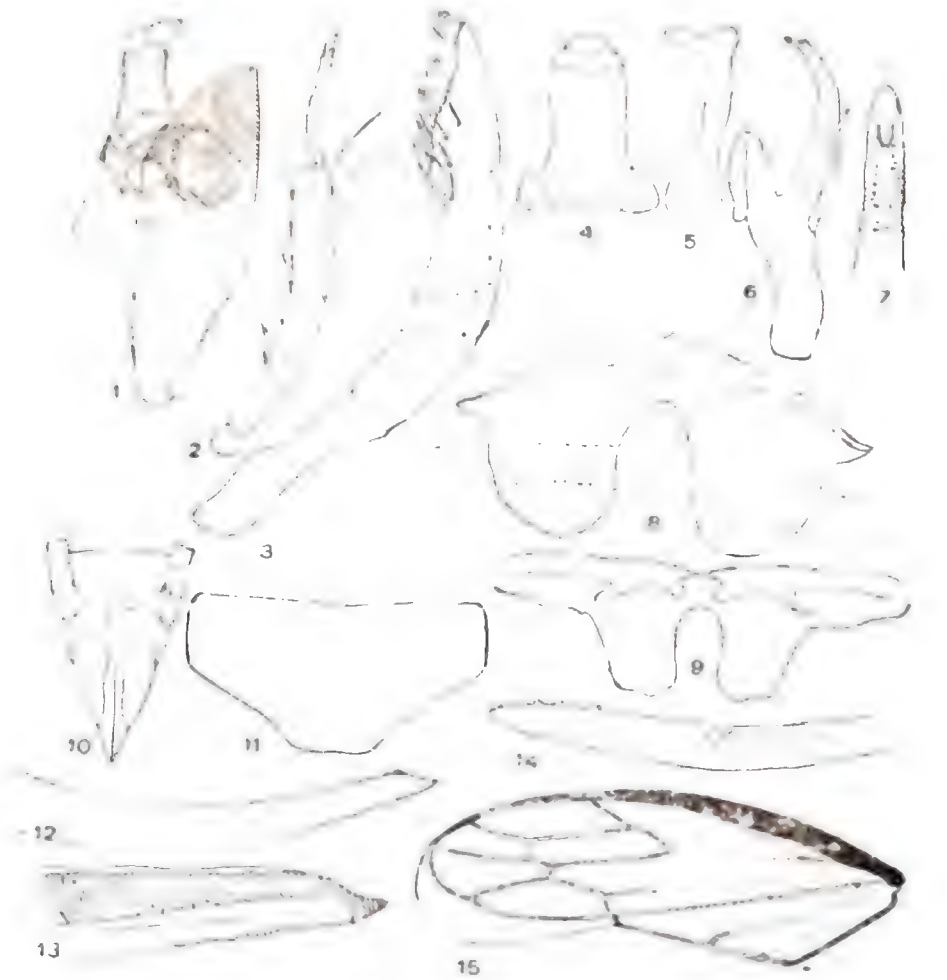
Face dorsad of ocelli and vertex transversely rugulose, rest of face shagreened. Frontoclypeus convex; clypellus widened apically. Labium long, extending up to hind coxae. Pronotum and scutellum shagreened. Pronotum 2.5 times as long as its median length. Scutellum 1.43 times longer than pronotum. Forewing veins margined by circular pits on either side in their basal half, these pits being more prominent along claval veins. Two subapical cells, the outer one closed behind. Apodemes at base of abdomen as in Figs. 8 and 9.

Male genitalia: Pygofer elongate, caudally angulately pointed, with a long single ventral process and an angular projection on ventral margin. Tenth segment with ventrally directed process.



Figs. 1—15. *Busoniomimus manjunathi* sp. nov.: 1. Pygofer; 2. Male plate; 3. Male style, 4. Connective, dorsal view; 5. Connective, lateral view; 6. Aedeagus, lateral view; 7. Tip of shaft, caudal view; 8. Tergal abdominal apodemes; 9. Sternal abdominal apodemes; 10. Ovipositor; 11. Female seventh sternum; 12 Gonapophysis I; 13. Gonapophysis II; 14. Gonapophysis II; 15. Left forewing.

Male plate perceptibly widened distally with long hair-like marginal setae. Style robust, anterior part before articulation nearly 1/2 as long as apophysis; the latter apically narrowed and with stouter setae on dorsal margin. Connective longer than wide, wider at base. Aedeagus with a strongly developed basal strut, dorsal apodeme short arising almost in the middle of aedeagus, shaft smoothly curved dorsally, much narrowed beyond gonopore; apical 1/3 pustulate; a pair of caudally directed processes arise at base of shaft. Gonopore subapical.

Female genitalia: Hind margin of seventh sternum broadly medially produced. Gonapophysis I pointed caudally the serrations extend to about half the caudal length. Gonapophysis II with 8 prominent teeth beyoned gonopore.

Measurements: Male 4.61 mm long, 1.64 mm wide across eyes; female 4.78 mm long, 1.69 mm wide across eyes.

Material examined: **Holotype** ♂, INDIA: KARNATAKA: Hebri (30 km NE of Udipi), 11.i.1984, ex mango Shashidhar coll. **Paratyye**: 7♂, 4♀, with data same as in holotype; 1♂, 1♀, INDIA: KARNATAKA: Yellapur, 15.xii.1983, Shashidhar Coll.; 1♂, INDIA: KARNATAKA: Dharmasthala, 16.i.1984, Shashidhar Coll.

Remarks: Webb (1983b) discussed the relationship among the six species of *Busoniomimus* Maldonado Capriles known from the Oriental Region and opined that these may belong to more than one genus. The genus is characterised by transversely striate vertex, long labium reaching to or beyond hind coxae, two anteapical cells (either closed or open behind), male pygofer with a dorsolateral fracture and a ventral triangulate lobe on each side, posterior margin of pygofer with or without an internal process, stem of the connective longer, aedeagal shaft pustulate. *B. manjunathi* is not closely related to any of the known species of *Busoniomimus* because of the presence of a pair of processes at the base of shaft making it an atypical member of the genus. In the key to the species of *Busoniomimus* given by Viraktamath and Murphy (1981) it runs down to *B. setulistylus* Viraktamath and Murphy from which it can be separated as follows.

Lower half of face black in male, dark brown in female; aedeagal shaft without process, style of male with a brush of setae on dorsal margin; female seventh sternum completely divided (Singapore)..... .... *B. setulistylus*

Face wholly ochraceous in both sexes; aedeagal shaft with a pair of basal processes, style of male with a few setae; female seventh sternum undivided (INDIA : KARNATAKA)..... *B. manjunathi*

Idioscopus anasuyae sp. nov. (Figs. 16-28)

Ochraceous. Two large black spots on upper part of face partially visible in dorsal view. Eye dark brown, outer area black. Lateral margin and posterior half of scutellum yellow. Forewing brownish, apical area fuscous, the 2nd and 3rd apical cells much darker apically; outer claval cell either entirely or near apex whitish yellow. Front tibia in male fuscous in basal and apical 1/3 on mesal area; stout setae dark brown; other legs ochraceous; the setae on R_2 and apical row of setal bases of hind tibia reddish; claws brown; third tarsomere of fore leg fuscous in both sexes.

Vertex and face dorsad of ocelli transversely rugulose, rest of face, pronotum and scutellum shagreened.

Frontoclypeus convex, wider than long, Clypellus wider at apex, lateral margin incurved, apex slightly extending beyond general curve. Labium reaching hind coxae. Pronotum 2.40 times wider than its median length. Scutellum 1.35 times longer than pronotum.

Male genitalia: Pygofer long, narrow, caudal half heavily pigmented. Anterior margin of genital capsule with well developed apodeme. Anal collar process complex, in dorsal aspect appearing bifurcate. Male plate membranous. narrow at base, widest at about basal 1/3 with marginal hair-like setae. Style strongly arched, apophysis longer than anterior part beyond articulation with connective; caudal half of apophysis broadened, ventral margin crenulate; with a subapical tooth and marginal setae. Connective as in Fig. 2. Aedeagus strongly sinuate, with well developed dorsal apodeme and basal strut; shaft broad at base narrowed and strongly curved dorsally with an apical hook and has a pair of lateral sinuate curved processes arising about midlength of shaft. Gonopore subapical.

Female genitalia: Seventh sternum almost semicircular. Ovipositor exceeding pygofer. Gonapophysis I fused on ventral line, striations occupy distal area. Gonapophysis II slender with 10 teeth on dorsal margin, its subapical margin minutely serrate both dorsally and ventrally; Caudal half of ventral area striated vertically.

Measurements: Male 3.72 mm long, 1.36 mm wide across eyes. Female 3.85 mm long and 1.41 mm wide across eyes.

Material examined: **Holotype** ♂, INDIA: KARNATAKA: Mangalore, 12.i.1984, ex-mango, Shasidhar Coll. **Paratype:** 8♂, 11♀, with same date as in holytype; 1♂, 1♀, INDIA: KARNATAKA: Kodyamalai (10 km E of Bantval), 13.i.1984 (♀), 15.i.1984 (♂), ex mango, Shasidhar Coll.

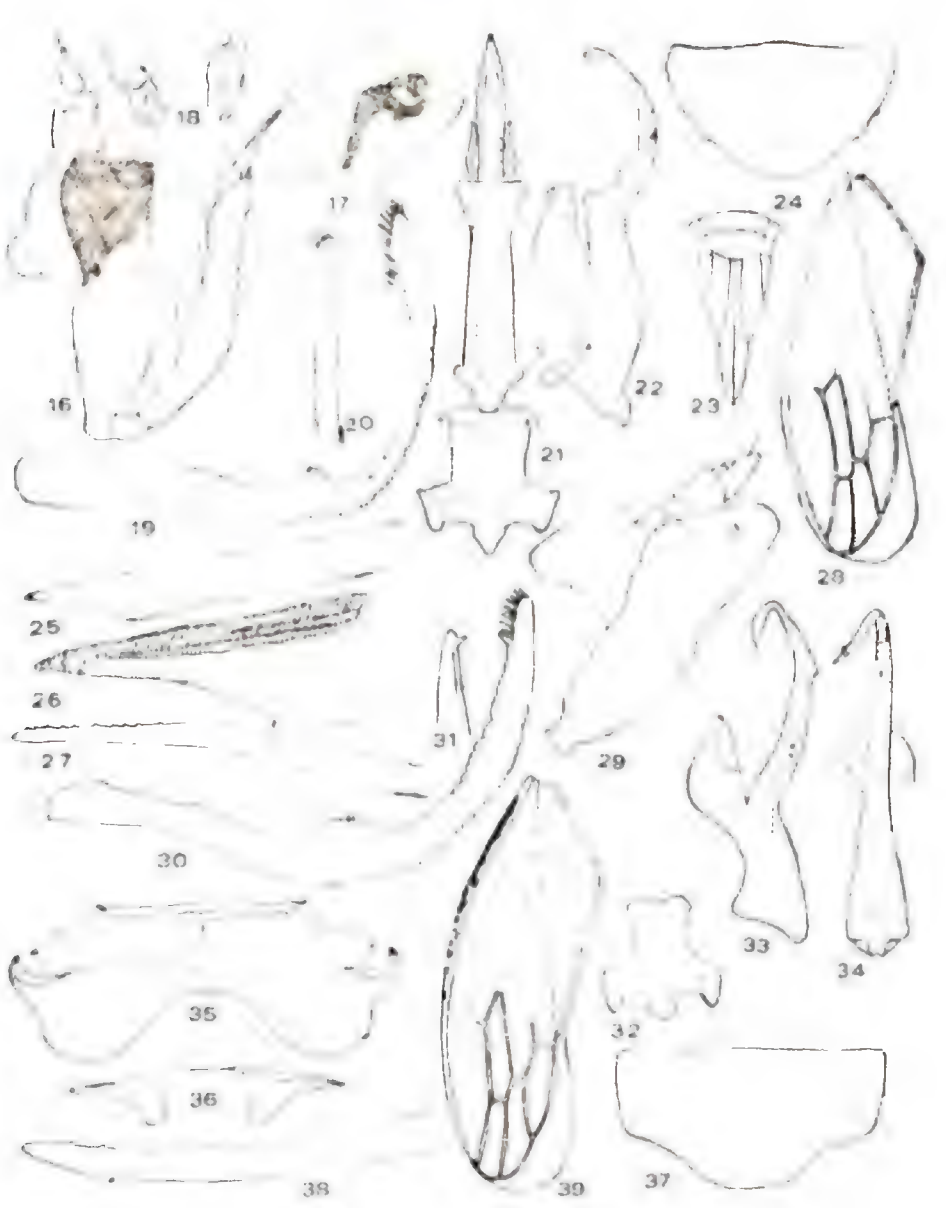
Remarks: This species resembles *Idioscopus dworakowskae* Viraktamath in the shape of the style and *I. spectabilis* in the shape of the aedeagus. However, it differs from both species in having processes to the aedeagal shaft and in the shape of the process on the tenth segment.

Idioscopus jayashriae sp. nov. (Figs. 29-39)

Head and pronotum ochraceous. Two large spots on upper part of face partly visible in dorsal aspect black. Scutellum ochraceous basally, greenish yellow laterlly and apically; basal angles and two semicircular lateral marginal shots, black. Clavus yellowish green (often interrupted by pale brown and in one female only basal area of clavus is yellowish green); apical area of forewing infuscated. Leg ochraceous; in male the distal half of fore tibia infuscated on mesal area, setae arising from this area dark brown; claws brown. Ovipositor black.

Vertex and face dorsad of ocelli transversely rugulose with a median sulcus; rest of face, pronotum and scutellum shagreened. Frontoclypeus convex. Clypellus wider at apex, produced beyond the outer margin of gena. Labium long, produced beyond hind coxae. Pronotum shagreened, 2.35 times wider than its length. Scutellum 1.33 times longer than pronotum. Apodemes at the base of abdomen as in Figs. 35 and 36.

Male genitalia: Pygofer with ventral margin sinuate in the middle longer than wide. Male plate wider in the long hair-like marginal setae. Tenth segment with well developed anterior



Figs. 16—39. *Idioscopus anasuyae* sp. nov.: 16. Pygofer and male plate; 17. Process of the segment X, lateral view; 18. Process of the segment X, dorsal view; 19. Male style; 20. Tip of apophysis of male style, caudal view; 21. Connective and aedeagus, dorsal view; 22. Aedeagus, lateral view; 23. Ovipositior; 24. Female seventh sternum; 25. Gonapophysis I; 26. Gonapophysis I showing striations; 27. Gonapophysis II; 28. Left forewing; 29—39. *Idioscopus jayashriae* sp. nov.: 29. Pygofer; 30. Male style; 31. Tip of apophysis of style; 32. Connective; 33. Aedeagus, lateral view; 34. Aedeagus, caudal view; 35. Tergal abdominal apodemes; 36. Sternal abdominal apodemes; 37 Female seventh sternum; 38. Gonapophysis II; 39. Left forewing.

apodemes, and with a pair of L-shaped caudoventral processes. Style strongly arched, apophysis almost twice as long as the part anterior to articulation with connective; apophysis slightly narrowed caudally with crenulate ventral margin and with a subapical tooth. Connective about as wide as long and as in Fig. 32. Aedeagus with a well developed basal strut which is 1/2 as long as shaft, dorsal apodeme well developed; shaft slender caudally directed with caudal denticle slightly before gonopore, shaft beyond gonopore attenuated and strongly anteriorly curved.

Female genitalia: Hind margin of seventh sternum broadly produced in the middle caudally. Ovipositor extending beyond pygofer. Gonapophysis I acutely pointed caudally. Gonapophysis II with 6 dorsal teeth which are placed almost equidistant, caudal margin serrate.

Measurements: Male 3.96 mm long, 1.39 mm wide across eyes; female 4.26 mm long, 1.45 mm wide across eyes.

Material examined: **Holotye** ♂, INDIA: KARNATAKA: Mangalore, 12.i.1984, ex mango, Shashidhar Coll. **Paratypes**: 1♂, 4♀, with same date as in holotype; 1♂, INDIA: KARNATAKA: Kodyamalai (10 Km E. of Bantval), 15.i.1984, Shashidhar Coll.

Remarks: This species resembles *I. spectabilis* in the shape of the aedegus and process of tenth segment and *I. dworakowskae* in the shape of the style. However, it can be differentiated from both the species in having tip of the aedeagal shaft attenuated and recurved and by the black spots on scutellum.

Webb (1983a, 1983b) segregated the Afrotropical and Australian species of Idiocerinae assigned to the genus *Idioscopus* Baker by earlier workers to a number of new genera. The 25 known species (excluding the two described here) from the Indian subcontinent (Ahmed *et al.*, 1980, Viraktamath, 1979, 1980; Viraktamath and Murphy, 1981) though show differences in both external and internal structures are placed in the genus *Idioscopus* pending a revision when more material becomes available from the Indian subcontinent.

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PROBABLE ROLE OF BRAIN-NEUROSECRETORY CELLS IN WATER BALANCE IN *ORYCTES RHINOCEROS* (COLEOPTERA : SCARABAEIDAE)

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In the scarabaeid beetle *Oryctes rhinoceros*, most of the 'A' type neurosecretory cells of the brain appear to elaborate a diuretic principle which is stored in the corpus cardiacum. However, one pair of the 'A' cells among them lying close to the median line elaborate an antidiuretic principle.

(Key words: Oryctes rhinoceros, neurosecretory 'A' cells, diuretic principle, antidiuretic principle)

During a study of the endocrines in the coconut rhinoceros beetle *Oryctes rhinoceros*, it was found that the brain neurosecretory cells of the larvae, which were reared in the laboratory on cowdung sprinkled liberally with water did not contain any neurosecretory colloids worth mentioning, when routine stains regularly employed for demonstration of neurosecretory cells were tried. However, those staining technicques easily demonstrated the colloids in the adult, which lived on rather dry food. So it was thought that the cells might be concerned with regulation of water metabolism in this animal and the present studies showed that our hypothesis was correct.

Third (final) instar larvae of the beetle *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) were reared in the laboratory on cowdung sprinkled generously with water. The adults were maintained on slices of ripe banana. For experimental purpose, the larvae were maintained on dry cowdung and withheld from water; larvae as well as adults were also injected either distilled water (1 ml/animal) or saline (1% saline, 1 ml/animal). Brain-corpus cardiacum complex was dissected out 3 days after experimental feeding, and injected animals were dissected out one day after treatment. Brain-cardicum complex was fixed in Bouin's fluid and paraffin sections were cut which were stained with Gomori's chrome alum haematoxylin phloxin (GOMORI, 1941) or aldehyde fuschsin technicque (GABE, 1953).

It is found that there are a number of 'A' type neurosecretory cells stainable blue with chrome alum haematoxylin in the pars-intercerebralis in the larvae as well as in the adult but the phloxinophil 'B' cells are fewer in number. The cardiacum has also plenty of colloids of 'A' type cells, in addition to their own intrinsic cells. The cardiacum is clearly a neurohaemal organ in this insect.

The larvae kept on cowdung liberally sprinkled with water had very little

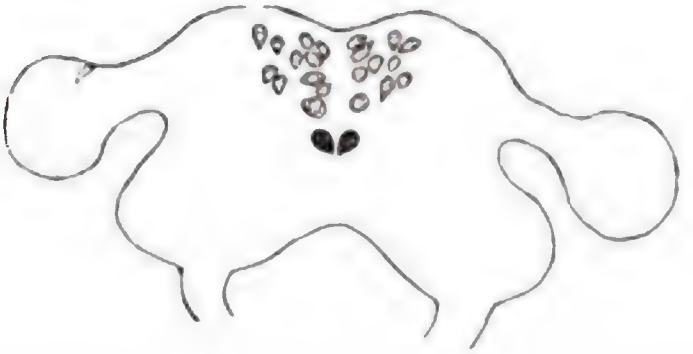

Fig. 1. Diagram of the brain of *Oryctes rhinoceros* illustrating the distribution of neurosecretory cells containing diuretic factor (lighter) and antidiuretic factor (darker).

colloids in most of the 'A' cells and in the corpus cardiacum. However in these animals one pair of neurosecretory cells among the group, close to one another and to the median line, were conspicuously loaded with secretory granules. In the larvae maintained on rather dry cowdung, most of the 'A' cells and the cardiacum were heavily loaded with scecretory colloids; the one pair of cells referred to above were not distinguishable. With injection of water there was deplection of colloids; with saline injection there was a tendency in the cells for accumulation of colloids, but the changes were not as drastic as providing or withholding of water from the food medium. Possibly more water/saline by injection was required, for drastic effects.

In the adults, there was a comparative depletion of neurosecretory material from 'A' cells and cardiacum after water injection whereas saline injection tended to accumulate colloids in the cells. In adults also one pair of cells among the group stood apart in water loaded animals and these were full of colloids as in the larvae.

From the above findings, it appears that most of the 'A' type neurosecretory cells and their axonal endings in the cardiacum in this animal, contained a diuretic principle, whereas a pair of neurosecretory cells in the brain close to the median line had probably an antidiuretic function. It is likely that the single pair of cells in the brain alone cannot counteract the whole effect of the large number of cells with diuretic principle; some other organ is likely to support the single pair of cells in their function.

It may be noted that the pars intercerebralis neurosecretory 'A' cells are reported to contain an antidiuretic principle in *Iphita limbata* (NAYAR, 1960), *Cenocorixa bifida* (JARIAL & SCUDDER, 1971) and in *Blabera fusca* (STUTINSKY, 1953) whereas neurosecretory material is supposed to be associated with a diuretic function in some other species of insects as in *Blaberus giganteus* (WALL & RALPH, 1962), *Carausius morossus* (PFLUGFELDER 1937), *Schistocerca gregaria* (HIGHNAM *et al*, 1965), *Melanoplus sanguinipes* (DOGRA & EWEN 1969), and in the beetles *Anisotarsus cupripennis* (NUNEZ, 1956)

and *Leptinotarsa decelineata* (De Wilde, 1966). In the present study, it appears that in *Oryctes rhinoceros*, most of the pars intercerebralis neurosecretory 'A' cells appear to be concerned with diuretic function, whereas one pair of cells appear to be antidiuretic, thus providing an example having hormones with antagonistic functions with reference to water balance (Raabe, 1982).

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COMPARATIVE KARYOLOGICAL STUDIES OF TWO CINARINE APHIDS (HOMOPTERA : APHIDIDAE) FROM KASHMIR VALLEY

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Two species of cinarine aphids, viz. *Cinara maculipes* H. R. L. 1966 and *C. tujafilina* (Del guercio 1909) have been studied cytologically. Their chromosome numbers are $2n = 10$ and $2n = 12$ respectively. Morphology and metrical analysis of the chromosomes of both the species have also been dealt with.

(Key words: aphids, cytotaxonomy)

INTRODUCTION

World fauna of lachnine aphids stands at 539 of which only 36 have been recorded from the Indian subcontinent (GHOSH, 1982). This group shows a high degree of endemism, which resulted in the restriction of 24 species and 2 subspecies to the region. Their recent origin, massive size and food plant preference have led the authors to study this group from the cytotaxonomical standpoint. So far only 33 cinarine aphid species have been cytologically investigated (KUZNETSOVA & SHAPOSHNIKOV, 1973; RUKAVISHNIKOV, 1974; BLACKMAN, 1980; PAL & KHUDA-BUKHSH, 1982).

Present study is a further addition to the knowledge on the cytotaxonomy of lachnine aphids and the results obtained are provided below.

MATERIALS AND METHODS

Cytological tool for the present investigation included *Cinara maculipes* H. R. L. 1966 and *Cinara tujafilina* (Del guercio, 1909), (Cinarini: Lachninae). Collection data for the above named species are as follows:

C. maculipes from *Pinus* sp. (Pinaceae), Bandipora (*C.* 5322) J. & K, 30.v.83, Coll. P. L. Das, *C. tujafilina* from *Thuja orientalis* (Cupressaceae), and also from some conifers otherwise stated as above.

For cytological preparations live gravid apterous viviparous females were teased with sharp needle and squeezed for taking out the embryos. Embryos, devoid of eye pigments were treated with 0.56% KCl (hypotonic solution) for 30—45 min, were used to have uniformely swollen and well spread chromosomes. They were then fixed in aceto-methanol (1 : 3 parts) for 15 min. Now following the usual procedure they were squashed and stained with Aceto-Orcein + Aceto-Carmine (1 : 1 parts) for 1 hour; mounted in Lacto-aceto-orcein and sealed with nail polish. After a week the stain matured and the slides were scanned under phase contrast microscope. Such temporary preparations could be kept in good condition for about two months. Diploid number of chromosomes of each species were determined from 50 well spread plates discarding the unusual $2n$ number. Such occurrence might be either as a result of dissociation or fusion of the elements of the normal diploid set or a technical fault.

Karyotypes and idiograms were constructed from 20 well spread and straightened metaphase plates of each species considering the relative percentage length (R^L) against the total chromosome complement (TCL) along with their actual length (vide Table 1). This compensated the variation of length of chromosomes due to different degree of condensation of the same at different stages and the technical errors. Failure in finding out the homologues led us to arrange the chromosomes in a descending order. Classification of chromosomes is based following KHUDA-BUKHSH (personal communication) : Excessive long (L^V) —>20% of R^L ; Long (L) —15—20%, Moderate (M) —10—15%, Small (S) —5—10% and excessive small (S^V) —<5%.

RESULTS

A) *Cinara tujafilina* (Del guercio, 1909)

The chromosomes (Figs. 1–6) are rod like and scattered at random, the diploid number counts 12 with a TCL of 33.9 ± 0.12 μm. But in a few cells chromosome count varies from 10–14, such aneuploid is considered to be due to asynchronous divisions of the chromosomes and/or rupturing of the two adjacent nuclei and displayed in a close area. Polyploidy occurs in this species at a lower rate. However, tetraploidy is more frequent which shows $2n = 24$, thus firmly eslablishes that the exact $2n$ number is 12. The longest one measures 5.12 ± 0.02 μm while the shortest one is 1.44 ± 0.12 μm. Rest of the chromosomes exhibit seriated decreasing variation in length. Chromosomes are classified into 4 types which exhibit 1L, 2M, 5S and 2 S^V .

B) *Cinara maculipes* H. R, L. 1966

Metaphase chromosomes (Figs. 7–9) are rod like and compactly arranged in a circular area. Diploid number is 10 with a TCL of 33.48 μm ± 0.80. The longest one measures 5.04 ± 0.10 μm while the shortest one is 1.87 ± 06 μm and the rest likewise show a gradual decrease in in length. Last two are exceptionally short in comparison to others. Chromosomes may be grouped into 3 categories; (a) long (1), (b) moderate (3) and small (6).

Interestingly, though the chromosome number varies in the two species, TCL is almost same in both the cases ($t = 0.52$ for 38 degrees of freedom i. e., the deviation is not significant; the two TCL values may be considered as same with a probability of 50–70%). But from the composite idiogram which is based on the R^L they are well distinguished by the relative size of the 3rd–8th chromosomes which exhibit marked variation in length in the two species. 1st & 2nd and 9th & 10th chromosomes of both the species are almost of same length.

DISCUSSION

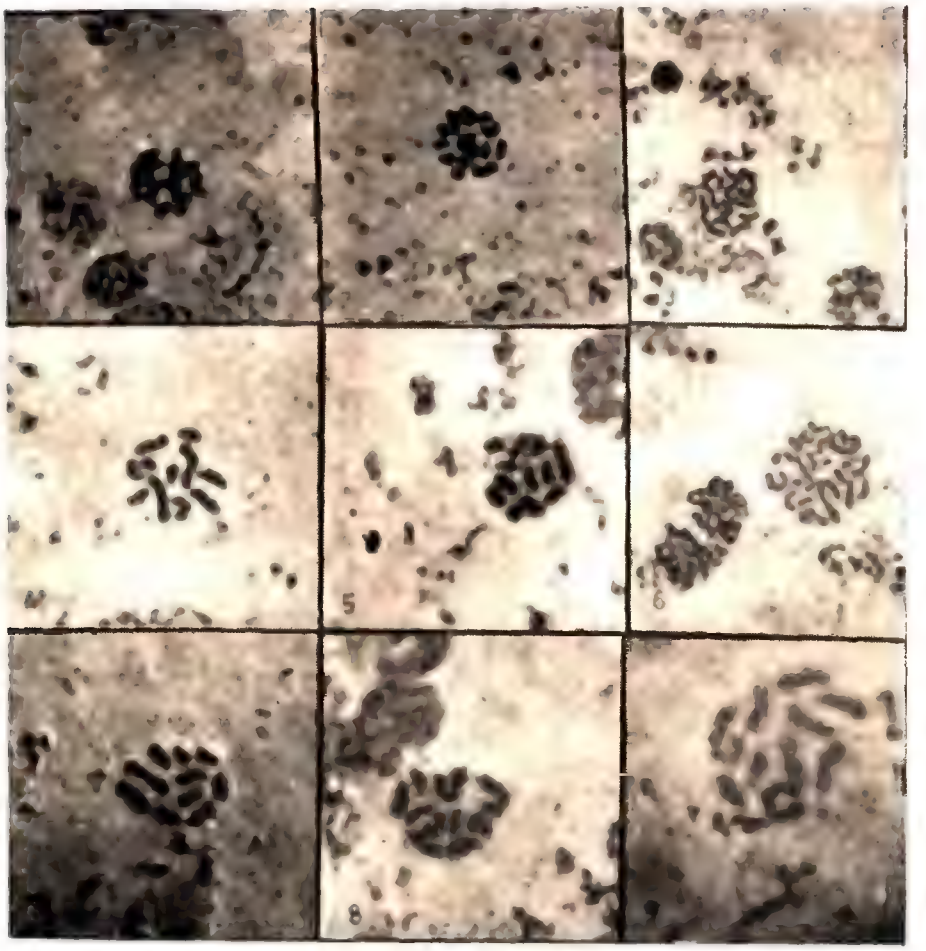
KUZNETSOVA & SHAPOSHNIKOV (1973) reviewed the works done on the karyology of aphids. The lachnids have been found to have $2n = 8–22$ while the cinarines have $2n = 10–22$ (KUZNETSOVA & SHAPOSHNIKOV. 1973). Such extreme variation has also been observed by us for *Cinara atrotibialis* DAVID & RAJASINGH ($2n = 22$, unpublished, vide Table 2). But the most predominant number is $2n = 10$ which may perhaps be considered as modal numbr for the group. Composite idiogram constructed both on the basis of actual and relative lengths of chromosomes (Fig. 10) revealed that the summation of the excess portion of chromosomes–numbering 3–8 of *C. maculipes* ($2n = 10$) fits well with the total length of the last two chromosomes of *C. tujafilina* ($2n = 12$). From this, it is evident that these two aphid species are probably

TABLE 1 Lengths of somatic metaphase chromosomes (Mean chromosome length in μm) of two species of *Cimara*

		No. of complements observed	Chromosome number												Mean TCL
			1	2	3	4	5	6	7	8	9	10	11	12	
Cimara tujaftina (Del guercio, 1969)	Actual length in μm	20	5.12 ± 0.02	4.97 ± 0.03	3.60 ± 0.03	3.13 ± 0.01	3.01 ± 0.09	2.65 ± 0.04	2.28 ± 0.02	2.15 ± 0.02	2.00 ± 0.06	1.88 ± 0.01	1.67 ± 0.01	1.44 ± 0.02	33.90±0.12 μm
	Relative length (%)		15.09 ± 0.06	14.65 ± 0.08	10.61 ± 0.10	9.22 ± 0.04	8.87 ± 0.04	7.81 ± 0.10	6.72 ± 0.06	6.33 ± 0.07	5.89 ± 0.06	5.54 ± 0.04	4.92 ± 0.05	4.24 ± 0.07	
Cimara maculipes H R L. 1966	Actual length in μm	20	5.04 ± 0.10	4.91 ± 0.01	4.01 ± 0.11	3.79 ± 0.09	3.10 ± 0.07	3.06 ± 0.06	2.89 ± 0.07	2.80 ± 0.08	2.01 ± 0.03	1.89 ± 0.06			33.48±0.80 μm
	Relative length (%)		15.05 ± 0.07	14.66 ± 0.09	11.97 ± 0.11	11.32 ± 0.17	9.25 ± 0.10	9.13 ± 0.09	8.62 ± 0.10	8.34 ± 0.10	5.99 ± 0.07	5.56 ± 0.07			

TABLE 2. Lengths of somatic metaphase chromosomes (Mean chromosome length in μm) of *Cinara atrotibialis* David and Rajasingh

	No. of complements observed	Chromosome number																					Mean TCL
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Actual length in μm	10	4.94 ± 0.04	4.94 ± 0.04	4.52 ± 0.03	4.08 ± 0.05	4.02 ± 0.05	4.00 ± 0.03	3.50 ± 0.05	3.34 ± 0.08	3.18 ± 0.03	3.02 ± 0.06	3.00 ± 0.05	2.90 ± 0.06	2.88 ± 0.05	2.86 ± 0.05	2.58 ± 0.06	2.52 ± 0.03	2.42 ± 0.03	2.04 ± 0.04	2.02 ± 0.03	1.80 ± 0.05	1.72 ± 0.05	1.70 ± 0.05	67.98 ± 0.44
Relative length (%)	10	7.26 ± 0.04	7.26 ± 0.04	6.64 ± 0.04	5.99 ± 0.04	5.91 ± 0.04	5.88 ± 0.03	5.14 ± 0.02	4.90 ± 0.11	4.67 ± 0.03	4.43 ± 0.03	4.41 ± 0.03	4.26 ± 0.05	4.23 ± 0.03	4.20 ± 0.04	3.79 ± 0.06	3.70 ± 0.02	3.55 ± 0.02	3.01 ± 0.03	2.96 ± 0.02	2.64 ± 0.04	2.52 ± 0.05	2.49 ± 0.04	



Photomicrographs of somatic chromosomes of cinarine aphids.

Figs. 1—5. Metaphase complements of *Cinara tujafilina* (Del Guercia) showing $2n = 12$; Fig. 6. Shows the teraploidy with $4n = 24$ of *C. tujafilina;* Figs. 7—9. Metaphase chromosomes of *Cinara maculipes* H. R. L. showing $2n = 10$.

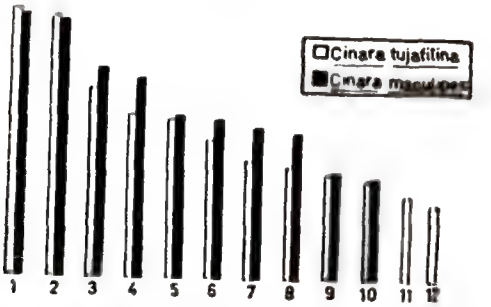


Fig. 10. Idiogram of the chromosomes of *Cinara tujafilina* Del Guercia and *C. maculipes* H.R.L

phylogenetically closely related and their chromosomes may have mutually evolved by the process of fusion and/or fission.

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EFFECT OF PUPAL REFRIGERATION IN SILKWORM UJI-FLY, *EXORISTA SORBILLANS* (WIEDEMANN) (DIPTERA : TACHINIDAE) ON FLY EMERGENCE AND LONGEVITY

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The puparia of the silkworm uji-fly, *Exorista scrbillans* (Wiedemann) of one, three, five, seven and nine days old were refrigerated for two, four, six, eight, ten, thirteen, sixteen and nineteen days and observations were made on fly emergence and longevity. With increase in pupal age and duration of refrigeration, the fly emergence tended to come down. Puparia of nine days age can be refrigerated for 13 days to get 80 per cent adult emergence. Adult longevity was maximum (28.33 days) with five days old pupae refrigerated for eight days.

(Key words: refrigeration, silkworm uji-fly, *Exorista sorbillans)*

INTRODUCTION

The uji-fly, *Exorista sorbillans* (Wiedemann) is a very important endoparasite of the mulberry silkworm, *Bombyx mori* L. in Karnataka. In West Bengal, 8% per cent of cocoon production was lost due to this fly. An average of 7.6 to 39.1 per cent cocoon infestation was noticed with a reduction of shell weight by 16.2 per cent (KRISHNASWAMI *et al.*, 1964). Due to its menace, the yield of the cocoons per 100 disease free layings was reduced to as low as 5 to 10 kg in many villages of Karnataka (ANONYMOUS, 1982). Several laboratory and field studies have been made on this fly. With a view to find out the suitable age of puparia and optimum duration of refrigeration that may help to synchronise the emergence of flies in the laboratory in large numbers for experimental purposes, investigation on uji pupal refrigeration was carried out and the results of the study are contained in this paper.

MATERIALS AND METHODS

The maggots of *E. sorbillans* were collected in large numbers from Ramanagaram cocoon market and allowed to pupate in soil in the plastic containers. The puparia of one, three, five, seven and nine days old were refrigerated at 5°C for 2, 4, 6, 8, 10, 13, 16 and 19 days in three replications of 10 puparia each. The puparia, after required duration of refrigeration, were kept in plastic containers at room temperature of 25 to 28°C for eclosion. The successful fly emergence and longevity by providing sucrose crystals have been recorded in different treatments and the data has been analysed statistically.

RESULTS AND DISCUSSION

Effect of pupal age before refrigeration: The per cent adult emergence varied from 22.04 to 92.08 with minimum and maximum being with one day and 7 day old refrigerated pupae, respectively while in control it was 90.00 per cent. It was highly significant between 9 days age (77.08 per cent) and other ages (Table 1).

TABLE 1. Effect of pupal refrigeration on per cent fly emergence of *E. sorbillans*

Duration of refrigeration (days)	Pupal age (days)												Control	
	1		3		5		7		9		Mean			
2	93.33	(77.70)	90.00	(75.00)	90.00	(71.56)	96.67	(83.85)	93.33	(77.71)	92.67	(77.16)	90.00	(75.00)
4	70.00	(57.00)	80.00	(63.44)	86.67	(68.85)	93.33	(81.15)	93.33	(77.71)	84.67	(69.63)		
6	13.33	(21.15)	90.00	(75.00)	76.67	(66.15)	100.00	(90.00)	83.33	(66.15)	72.67	(63.69)		
8	—	(0.99)	86.87	(68.85)	96.67	(83.85)	96.67	(83.85)	93.33	(77.71)	74.67	(63.05)		
10	—	(0.99)	90.00	(71.56)	83.33	(70.78)	73.33	(59.22)	73.33	(77.71)	64.00	(56.05)		
13	—	(0.99)	93.33	(77.71)	80.00	(58.85)	96.67	(83.85)	80.00	(64.63)	70.00	(59.21)		
16	—	(0.99)	83.33	(70.05)	86.67	(72.78)	90.00	(75.00)	53.35	(47.01)	62.67	(53.17)		
19	—	(0.99)	86.67	(68.85)	83.33	(70.77)	90.00	(75.00)	46.67	(42.99)	61.33	(51.58)		
Mean	22.04	(20.10)	87.50	(71.31)	85.42	(71.61)	52.05	(78.99)	77.08	(66.45)				

	F-test	SEM ±	CD 5%	CD 1%
Age of pupa :	**	2.28	6.3359	8.3272
Duration of refrigeration :	**	2.89	8.0144	10.5332
Interaction between age of pupa and duration of refrigeration :	**	6.46	17.9207	23.5529

Figures in the parentheses are angular transformed values.

Significant difference in adult longevity was observed amongst one, three and five days old refrigerated pupae (6.50, 14.21 and 11.67 days) (Table 2).

Effect of duration of refrigeration of different aged pupae: Irrespective of age of pupae, the adult emergence varied from 61.33 to 92.67 per cent being minimum and maximum at maximum duration of refrigeration (19 days) and minimum duration of refrigeration (2 days), respectively.

Adult longevity was observed to increase gradually with duration of refrigeration from 2 to 8 days and thereafter fell gradually, the minimum (8.00 days) being encountered with 19 days refrigerated pupae compared to 15.66 days for flies from unrefrigerated pupae (Table 2).

Influence of interaction between pupal age and duration of pupal refrigeration: Significant difference was noticed in adult emergence when one day old pupae were refrigerated for different durations. With refrigeration of three, five and seven days old pupae, the adult emergence was similar.

There was no adult emergence when one day old pupae were refrigerated for 8 to 19 days. Further, the emergence of the adults was inconsistent when three, five and seven days old pupae were refrigerated. The adult emergence with 16 and 19 days pupal refrigeration was

TABLE 2. Effect of pupal refrigeration on adult longevity of *E. sorbillans* (in days).

Duration of refrigeration (days)	Pupal age (days)						
	1	3	5	7	9	Mean	Control
2	7.67	6.33	6.33	6.33	4.33	6.2	15.66
4	27.00	14.00	5.33	7.67	6 00	12.00	
6	17.33	26.33	13.33	14.67	6.33	15.6	
8	—	18.67	28.33	17.33	25.00	17.87	
10	—	12.00	18.00	20 33	25.33	15.13	
13	—	13 67	8.67	15 00	12.00	9 87	
16	—	10.67	5.33	14.33	10.00	8.07	
19	—	12.00	8.00	12.00	12.00	8.00	
Mean	6.50	14.21	11.67	13.46	12.62		

	F-Test	SEM ±	CD 5%	CD 1%
Age of pupae:	• •	0.937	2.5968	3.4130
Duration of refrigeration:	• •	1.18	3.2848	4.3172
Interaction between age of pupa and duration of refrigeration:	• •	2.65	7.3450	9.6534

significantly less (46.67 to 53.33) with nine days old pupae compared to that with three, five and seven days old pupae refrigerated for the same period. Adult longevity was almost similar with 10 days refrigeration. It varied from 8.67 to 15.00 days when different aged pupae were refrigerated for 13 days, and with 16 days refrigeration it was 5.33 to 14.33 days compared to 15.66 days in control.

Specific literature on this aspect of study is little for discussion. The fly emergence tended to come down with increase in the pupal age and duration of refrigeration. However, nine days old puparia of *E. sorbillans* can be safely refrigerated for 13 days without causing significant detrimental effect for fly emergence.

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MEIOTIC CROMOSOMES AND SEX MECHANISM IN MALES OF TWELVE SPECIES OF HETEROPTERA

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Diploid and haploid chromosome numbers and sex mechanism have been determined in 12 species of Heteroptera viz, *Eusthenes eurytus* ($2n$ ♂ = $10+XY$) and *Eusthenes robustus* ($2n$ ♂ = $10 + XY$) of the family Tessaratomidae, *Picromerus* sp ($2n$ ♂ = $12 + XY$), *Placosternum taurus* ($2n$ ♂ = $12 + XY$), *Tolumnia latipes* ($2n$ ♂ = $12 + XY$) and *Eumenytes* sp. ($2n$ ♂ = $12 + XY$) of the family Pentatomidae, *Physopelta gutta* ($2n$ ♂ = $12 + m + X_1 X_2 Y$) and *Physopelta guadriguttata* ($2n$ ♂ = $12 + 2m + X_1 X_2 Y$) of the family Largidae, *Notobitus excellens* ($2n$ ♂ = $18 + 2m + XO$), *Daladar planiventris* ($2n$ ♂ = $18 + 2m + XO$), *Derepteryx hardwicki* ($2n$ ♂ = $20 + 2m + XO$) and *Petillia patullicollis* ($2n$ ♂ = $24 + 2m + XY$) of the family Coreidae. Supernumerary chromosomes have been encountered in *Picromerus* sp. and *Eumenotes* sp. In all the species, the general course of meiosis is normal and the sex chromosomes are postreductional.

(Key words: meiotic chromosomes, sex mechanism. Heteroptera)

A perusal of the literature on the cytology of Heteroptera reveals that the chromosomes of approximately 1,200 species belonging to 40 families have been investigated. The chromosome number and sex mechanism in Heteroptera were listed time to time by various workers (MAKINO, 1951, 1956; TAKENOUCHI & MURAMOTO, 1969; UESHIMA, 1979; MANNA & DEB MALLIK, 1981; MURAMOTO, 1982). Based on these cytological data, the evolutionary inter-relationships between various groups of Heteroptera were attempted by MANNA (1956, 1962, 1984), UESHIMA (1979), LESTON (1956, 1957), BANERJEE (1968), MURAMATO (1977). In the present communication, the meiotic chromosome constitution and sex determining mechanism in 12 species of Heteroptera have been reported for the first time and are presented in the Table 1.

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TABLE 1. Diploid and haploid chromosome numbers and sex mechanism in 12 species of Heteroptera. (Abbreviations: s = spermatogonial, MI & MII = primary and secondary spermatocytes, *m*-chr = microchromosome, s-chr = supernumerary chromosome).

Species	Chromosome number			Sex mechanism	Remarks
	$2n$	n			
		MI	MII		
Family—TESSARATOMIDAE					
1 *Eusthenes eurytus*	12s	7	6	XY	
2 *Eusthenes robustus*	12s	7	6	XY	
Family—PENTATOMIDAE					
3 *Picromerus* sp.	14s	8	7	XY	s-chr
4 *Placosternum taurus*	14s	8	7	XY	
5 *Tolumnia latipes*	14s	8	7	XY	
6 *Eumenotes* sp.	14s	8	7	XY	s-chr
Family—LARGIDAE					
7 *Physopelta gutta*	17s	10	8	X_1X_2Y	*m*-chr
8 *Physopelta quadriguttata*	17s	10	8	X_1X_2Y	*m*-chr
Family—COREIDAE					
9 *Notobitus excellens*	21s	11	11	XO	*m*-chr
10 *Daladar planiventris*	21s	11	11	XO	*m*-chr
11 *Derepteryx hardwicki*	23s	12	12	XO	*m*-chr
12 *Petillia patullicollis*	28s	15	14	XY	*m*-chr

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THE CYTOLOGY OF INDIAN COLEOPTERA. I. A STUDY OF CHROMOSOMAL BEHAVIOUR DURING MEIOSIS IN FIVE SPECIES OF COLEOPTERA FROM THE EASTERN HIMALAYAS

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Meiotic chromosomes of five species of Coleoptera viz, *Epicauta nepalensis* (Hope) ($2n$ ♂ = 20: $n = 9AA + Xy_r$) of the family Meloidae; *Melanauster strandi* Breur ($2n$ ♂ = 18) and *Dihammus ceruinus* Hope ($2n$ ♂ = 20: $n = 9AA + Xy_p$) of the family Cerambycidae; *Mimela princeps* Hope ($2n$ ♂ = 19: $n = 9AA + XO$) of the family Scarabaeidae and *Lacon* sp. ($2n$ ♂ = 17: $n = 8AA + XO$) of the family Elateridae have been studied. The behaviour of chromosomes during meiosis is orthodox in all the species. The first meiotic division is reductional while the second division is equational for the sex chromosomes. Results have been compared with modal numbers and sex determining mechanisms of Meloidae, Cerambycidae and Elateridae.

(Key words: chromosomes, meiosis, Coleoptera)

INTRODUCTION

Although in the last two decades our knowledge on Coleopteran chromosomes has accumulated rapidly, the chromosomal data of the Meloidae (SMITH, 1953; VIRKKI, 1962b; MANNA & LAHIRI, 1972; DASGUPTA, 1977), Cerambycidae (SMITH, 1953; 1950; 1960a; MANNA & LAHIRI, 1972; TAKENOUCHI, 1978), Scarabaeidea (SMITH, 1950, 1953, 1960a; VIKKKI, 1967a; MANNA & LAHIRI, 1972; DASGUPTA, 1974a, 1977) and Elateridae (SMITH, 1953, 1960a; MANNA & LAHIRI, 1972; DASGUPTA, 1977) are still meagre. With a view to extend our knowledge on Coleopeteran chromosomes, we have undertaken a cytological survey of Indian Coleoptera. The present paper incorporates an account of the meiotic chromosomes of five species of Coleoptera from the Eastern Himalayas.

MATERIALS AND METHODS

The following species of Coleoptera constitute the materials for the present study: Family-Meloidae : *Epicauta nepalensis* (Hope), Family-Cerambycidae: *Melanauster strandi* Breur and *Dihammus ceruinus* Hope, Family-Scarabaeidae : *Mimela princeps* Hope, Family : Elateridae: *Lacon* sp. All the species were collected from Darjeeling (altitude-2134 metre) during May to July, 1982—1984. Testes from the male individuals were fixed in 1:3 acetic alcohol and the chromosome preparation was made following the squash technique described earlier by DEY *et el.* (1984).

RESULTS

Family Meloidae

Epicauta nepalensis: Spermatogonial metaphase plates show 20 chromocomes (Fig. 1). The size difference between the chromosomes is gradual. While the *Y* chromosome is the smallest member of the complement, the *X* chromosome

is indistinguishable from the autosomes. At metaphase I (Fig. 2), nine autosomal bivalents are dumbell shaped in appearence and the association between the sex chromosomes is of Xy_r type. The *Y* coromosome is minute and remains attached at the end of larger *X* chromosome. There are two types of secondary spermatocytes: $9A+X$ (Fig. 3) and $9A+Y$. Hence as in all other members of Meloidae, the sex chromosomes undergo prereduction.

Family Cerambycidae

Melanauster strandi: Spermatogonial metaphase plates reveal the presence of 18 chromosomes (Fig. 4). The seriation of the size of the cromosomes is gradual. The sex determining mechanism, however, could not be ascertained due to lack of primary spermatocytic stages.

Dihammus ceruinus: The first metaphase consists of four large and five medium autosomal bivalents and a small Xy_p sex bivalent (Fig. 5). The sex determining Xy_p bivalent stands out in the haploid set and *Y* chromosome is the smallest member of the complement.

Family Scarabaeidae

Mimela princeps: The first metaphase shows 10 elements comprising nine autosomal bivalents and an univalent *X* chromosome (Fig. 6). Among the autosomal bivalents, there are three large and size seriation of other bivalents is gradual. The *X* chromosome is the smallest member of the complement and sex determining mechanism is *XO* type.

Family Elateridae

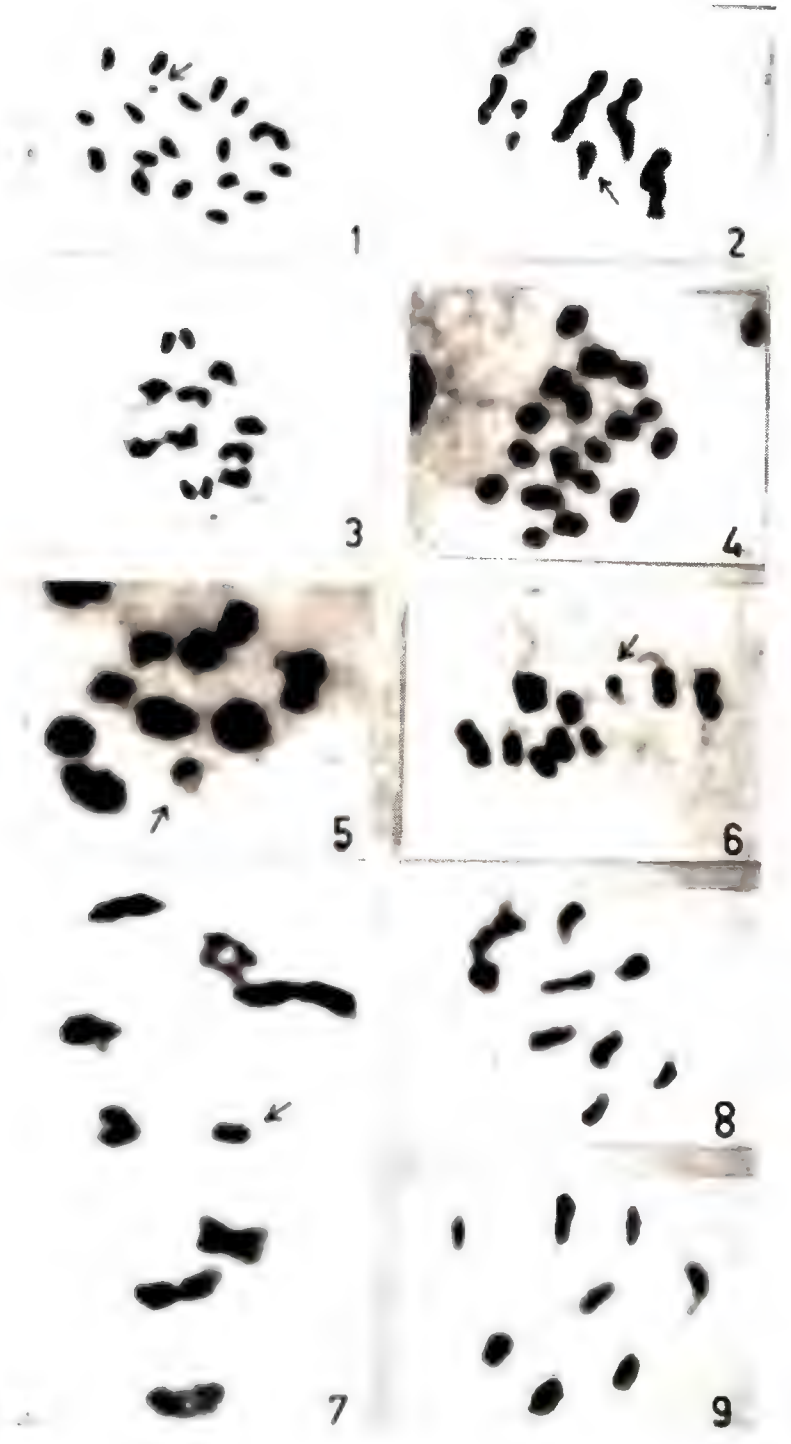
Lacon sp.: The haploid chromosome complement as revealed by the first metaphase division is eight (Fig. 7). It contains seven autosomal bivalents and an univalent *X* chromosome. The largest bivalent stands out in the complement and size seriation of other seven bivalents is gradual. The *X* chromosome is the smallest member of the complement and the sex determining is *XO* type. There are two types of secondary spermatocytes: one of them contains eight autosomal elements plus *X* (Fig. 8), the other eight autosomes only (Fig. 9). Thus, the sex chromosomes undergo prereduction.

DISCUSSION

Meloidae: The chromosomes of about 17 species of the family Meloidae have been reported by various workers (SMITH, 1953; VIRKKI, 1962 b; MANNA & LAHIRI, 1972; DASGUPTA, 1977). The modal number of this family seems to be $2n = 20$ with prevalence of Xy_p sex determining mechanism. However, *Xy* and Xy_r types of associations are also encountered. The genus *Epicauta* is also characterized by the basic meloid formula $9AA+Xy_p$, except *Epicauta grammica* (VIRKKI, 1962 b) with $2n = 22$, *Epicauta cinerea* and *Epicauta pennsylvanica* (SMITH, 1953) with *Xy* sex determining mechanism. However,

EXPLANATION OF FIGURES

Figs. 1—9. (×1000) 1. Spermatogonial metaphase of *E. nepalensis* showing *y* chromosome; 2. Metaphase of *E. nepalensis* showing Xy_r bivalent; 3. Metaphase II of *E. nepalensis* showing $9A+X$; 4. Spermatogonial metaphase of *M. strandi* showing 18 chromosomes; 5. Metaphase I of *D. ceruinus* showing Xy_p bivalent; 6. Metaphase I *M. princeps* showing *X* chromosome; 7. Metaphase I of *Lacon* sp. showing *X* chromosome; 8. Metaphase II of *Lacon* sp. showing $8A + X$; 9. Metaphase II of *Lacon* sp. showing 8 autosomes.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Epicauta nepalensis studied in the present investigation has chromosome formula $9AA - Xy_1$ which differs from the basic meloid formula in respect of sex determining mechanism. These facts suggest that the genus *Epicauta* is a heterogeneous group with Xy_p, Xy and Xy_1 types of sex determining mechanisms.

Cerambycidae: Our knowledge on the chromosomes of Cerambycid beetles is limited to 52 species only (SMITH, 1950, 1953, 1960a; MANNA & LAHIRI, 1972; TAKENOUCHI, 1978). The diploid chromosome number ranges from 10 to 32 with predominantly Xy_p sex determining mechanism. However, *XO* mechanism has been reported earlier in *Stromatium barbatum* by MANNA & LAHIRI (1972). Two species under present investigation *M. strandi* & *D. cerunius* have diploid chromosome number of 18 and 20 respectively with Xy_p sex determining mechanism in the latter. With the insufficient chromosomal data presently available it is not desirable to speculate on the modal number of Cerambycidae.

Scarabaeidae: The chromosomes of about 113 species of Scarabaeidae have been reported (SMITH, 1953, 1960 a; VIRKKI, 1967 a; MANNA & LAHIRI, 1972; DASGUPTA, 1974 a, 1977). The diploid number varies from 12 to 25 with a very high frequency of 20. Though *Xy* is much more frequent than Xy_p, *XY* and neo-*XY* are also found. *Mimela princeps*, studied here, has $2n♂ = 19$ with *XO* sex determining mechanism. The *XO* sex mechanism is rather rare in the family Scarabaeidae and only one species has been known so far to have *XO* mechanism: *Apogonia nigricans* Hope (MANNA & LAHIRI, 1972).

Elateridae: The chromosomes of about 54 species of Elateridae have been studied by various workers (SMITH, 1953, 1960 b; MANNA & LAHIRI, 1972; DASGUPTA, 1977). The diploid number ranges from 10 to 22 with most frequent number of 19, while the sex determining mechanism is *XO* type, the Xy_p and neo-*XY* are also quite frequent. However, the diploid chromosome number of 17 ($8AA + XO$) of *Lacon* sp. which has been reported in the present investigation deviates from the common diploid number of Elateridae. The diploid chromosome number of 17 ($8AA + XO$) has been reported only in two other species of this family: *Heteroderes macroderes* (MANNA & LAHIRI, 1972) and *Agnypnus fuscipes* (DASGUPTA, 1977). The *XO* sex determining mechanism which is present in a minority of species of Coleoptera, might have originated from the more commom *XY* type by the evolutionary loss of *Y* chromosome (WHITE, 1973).

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DUAL PATTERN IN THE MATING BEHAVIOUR OF THE MANTID *HUMBERTIELLA SIMILIS* G. TOS (MANTODEA, MANTIDAE)

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The present paper deals with the mating behaviour of the mantis, *Humbertiella similis* as observed in the laboratory. The peculiar feature is the change in basic predator-prey relationship between female and male to sexual behaviour. The female is a predator on males and tries to devour the male till she is forced to switch over to sexual behaviour during copulation.

(Key words: courtship, mating behaviour, predator-prey relationship, *Humbertielia similis*)

INTRODUCTION

The complex courtship and mating activities in mantis are of unusual interest and various authors have noted that the females devour the males either before, during or after copulation (HOWARD, 1886; RILEY & HOWARD, 1892; ROEDER, 1935). KELNER-PILLAULT (1957) and EDMUNDS (1972, 1975) worked out the courtship, mating and possible sex pheromones in various species of mantids. ROEDER (1967) and ROEDER *et al.* (1960) made an extensive study on the effect of decapitation on the courtship and mating behaviour of *Mantis religiosa*. However, observations on the sexual behaviour of *Humbertiella similis* are lacking and therefore in the present investigation experiments are performed to study the male-female relationship and mating success in present species.

MATERIALS AND METHODS

The mating behaviour was observed on the males and females *Humbertiella* reared in the laboratory. A number of behavioural measures were taken by keeping both the sexes in a glass jar. In total 30 pairs were observed.

RESULTS

Out of 30 pairs only 22 copulated successfully without being eaten up. Only four males were attacked and devoured even before mounting, one male was chased away by the female and the other one although succeeded in mounting, failed to copulate because the female remained unreceptive. Two males were devoured by females, one after copulation and the other immediately after mounting when she started eating his head, thus inducing violent copulatory movements in male such as turning and peristaltic movements of the abdomen. The male finally succeeded in mating.

The courtship ritual can arbirtarily be divided into *Pre-contact events* from the orientation to mounting and *Post-contact events*, which include actual copulation. At the end of copulation the sexual interaction gets over and the two

individuals revert back to predator-prey relationship.

It is assumed that the sexual interaction begins with the signal provided by the pheromones from the mature female, as was seen in the pairs whose eyes were painted black with India ink. It is believed that this volatile substance diffuses in the air and is detected by the male as inferred from the scanning movements of his antennae observed when the blinded male and the female were 7.5 inches apart.

Since the predator-prey behaviour between the two sexes is strong, the sexual acceptance of the male is only temporary so long as he holds her valvulae. Before this the female may attempt to stop or avoid male courtship in several ways:

(1) In the pre-contact phase, if the female first catches sight of the male, he is immediately approached, grasped and promptly devoured: the predator-prey behaviour.

(2) During the initial contact phase the female may struggle violently to shake the male off her back.

(3) The female may not open her ovipositor valves so that the male is unable to establish genital contact. The female being larger and stronger than the male, the latter is at her mercy.

DISCUSSION

The courtship and mating activities in mantis involve a complex behaviour pattern of unusual interest, because it very ingeniously breaks the basic predator prey relationship for a short period. It is interesting to see how the predator-prey behaviour connected with feeding changes to sexual behaviour as the females devour the males either before or during or after the copulation (HOWARD, 1886; RILEY & HOWARD, 1892; ROEDER, 1935, 1967; EDMUNDS, 1975). The pheromone produced in mature female is released and diffuses in the air. The male detects the pheromone by the receptors located on the antennae and reacts by the scaning movement of the antennae. However, the female continues the role of a predator until it is successfully aroused by the male by tactile stimulus in the post-contact phase. Similar observations were recorded by EDMUNDS (1975) in *Oxypilus hamatus*, *Tarachodes afzelli* and *Sphodromantis lineola*. The copulatory success is recorded highest (80%) in the present investigation whereas it is very low in EDMUNDS, (1975) experiments which suggested that unless there is an excess of males in the population, most of the females remain unmated. Since the males are not in excess in the population as reported by EDMUNDS (1975) and most females caught from fields lay fertile ootheca, it seems that mantis behave differently in captive conditions.

There is no display of any kind in *H. similis* and for the females, male is a potential prey. The male mantis on noticing the female becomes motionless and lacks any kind of display. From the observations, it is assumed that the starting point in the courtship behaviour is the signal from the pheromone which modulates or modifies the prey behaviour of the male to the sexual behaviour and sets him after the trail of the predator female. However, olfactory stimulation is not enough clue in locating the mate and a variety of other stimuli such as vision and touch are needed.

ROEDER (1935, 1967) gave a detailed account of cannibalism during mating in

Mantis religiosa. According to his observations, decapitation (destruction of suboesophageal ganglion) induces in the male, violent attempt to copulate a series of rotatory movements carrying his thorax and abdomen over the back of the female in the mating postures. This activity is not observed in the intact male unless the female is clasped by his phallomeres. This inhibitory influence is temporarily counteracted in the intact male by contact with the female and may be permanently removed, by experimental decapitation or attack by the female, a device that permits fertilization and at the same time nourishment for the developing ovaries. In the experiment with the present species, a male attacked by the female and his head devoured by her, showed violent copulatory movements (turning and peristaltic movements of the abdomen) but his headless torso succeeded in mating. This observation confirms Roeder's work on *Mantis religiosa* (1935).

The analysis of behaviour shows that any instinctive behavior pattern is considered to be comprrised of appetitive behaviour and consummatory act (LORENZ, 1950; TINBERGEN, 1951). CRAIG (1918) was the first to distinguish the stereotyped consummatory action from the more variable initial appetitive behaviour, which is a search for the appropriate releasing stimulus situation. In *Humbertiella similis*, the appetitive behaviour starts with the male visually identifying the female and ends as soon as the male holds the valvulae of the female and copulation (transfer of spermatophore to the female genital chamber) can be identified as consummatory act since it terminates the courtship sequence and brings back the primary survival behaviour, the predator-prey relationship between the female and the male.

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NEW RECORD OF *DIAPHORINA DAKARIENSIS* BOSELLI AND *EUPHALERUS MARGINALIS* CAPENER (HOMOPTERA: PSYLLIDAE) FROM INDIA

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Two species of psyllids viz., *Diaphorina dakariensis* Boselli and *Euphalerus marginalis* Capener collected respectively from *Leptadenia reticulata* W & A. and *Cassia marginata* are reported for the first time from India.

(Key words: new record of psyllids, *Diaphorina dakariensis, Euphalerus marginalis)*

Nine species under the genus *Diaphorina* and one under *Euphalerus*, both belonging to the subfamily Psyllinae (Homoptera: Psyllidae), are known to occur in the Indian subcontinent (MATHUR, 1975). In this paper two more species viz., *Diaphorina dakariensis* Boselli and *Enphalerus marginalis* Capener are added as new records to the Oriental psyllid fauna.

During May–June *D. dakariensis* was found to occur in large numbers infesting *Leptadenia reticulata* W & A (Asclepiadacae) at Madras. The infested leaves were crinkled inwardly and growth of the vine was impaired (Fig. 1). The nymphs generally occur on the upper surface of the leaf and were covered with white waxy secretion. The adult population was low during July–Aug. *D. dakariensis* was originally described from Senegal in West Africa (BOSELLI, 1930) and since then no information is available about its occurrence in other regions.

Similarly, *Euphalerus marginalis* Capener was also collected from the plant *Cassia marginata* (Leguminosae) at Madras, during December. It was first described from South Africa (CAPENER, 1973) on the plant *Burkea africana*. In India, MATHUR (1975) reported the occurrence of only one species viz., *E. vittatus* and hence the present report on the occurrence of *E. marginalis* forms a new record.

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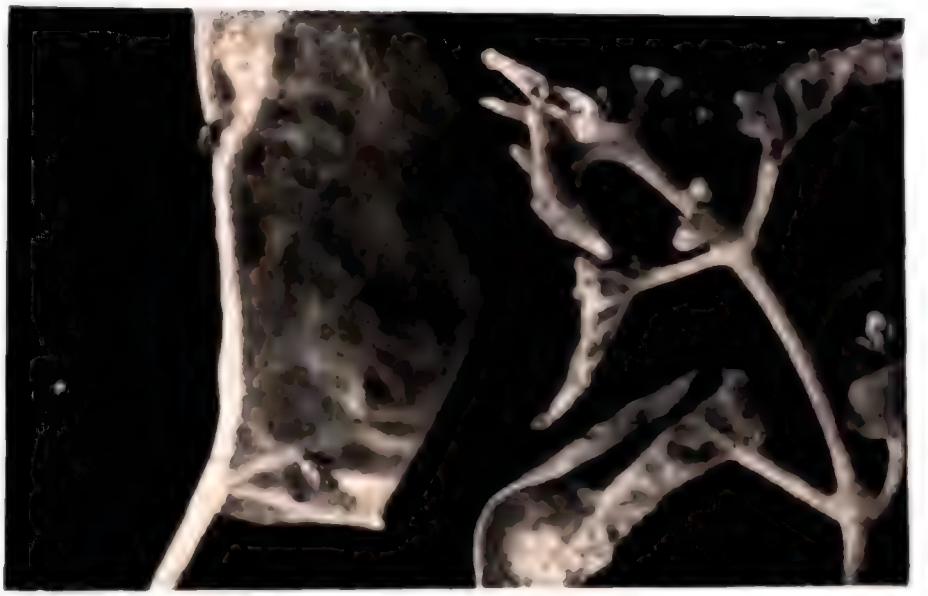

Fig. 1. Leaves of *Leptadenia reticulata* infested by *Diaphorina dakariensis*

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Entomon, 1985, *Vol.* **10**, *No.* 4, *pp.* 341

BOOK REVIEW

INVERTEBRATE EMBRYOLOGY by R. NAGABHUSHANAM & R. SAROJINI, Oxford & IBH Publishing Co., New Delhi, 1985, 580 pp, Rs. 55.50.

Books on invertebrate embryology are very few though the considerable literature pertaining to classical embryology of many invertebrates has been occasionally reviewed and organized into chapters by various authors in their books on invertebrates. Students in India have been especially experiencing the dire need for a comprehensive book to cater to their need in this field for quite some time. *Invertebrate Embryology* will satisfy this long-felt need to a great extent. The teaching community in India will also find this book quite useful. It deals with almost all the invertebrate groups, Porifera, Cnidaria, Ctenophora, Platyhelminthes, Nemathelminthes, Bryozoa, Phoronida, Brachiopoda, Annelida, Arthropoda (almost half the book being justifiably set apart for this group), Mollusca and Echinodermata. Attempt has been made to lay emphasis on development of types while comparative aspects have not been lost sight of and one feels the treatment is more or less balanced. Allied topics like metamorphosis, regeneration, asexual reproduction etc. have also been necessarily included, as also experimental embryology of the groups. There is also an index of eight pages.

Though there are frequent references in the text, a Bibliography is sadly lacking, which is perhaps the major drawback of the book. The book is well illustrated with sufficient figures throughout, which makes it quite understandable. It is comparatively free from mistakes; hardbound with a nice jacket, the book is available at the subsidised rate of Rs. 55.50 which most libraries will find affordable and students and teachers will find a boon.

V. K. K. Prabhu

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